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Improvements in Hinged Match-plate Work

The Practice of a Canadian Stove Plate Foundry Employing These Labor-Saving Molding Devices

HINGED match-plates effect great molding economies and are widely used in foundries specializing in stove plate and other light work. There are still, however, many shops that have failed to take advantage of this labor-saving device and some foundries are using match-plates without reaping the full benefit of their possibilities. Although the fundamental principles in match-plate practice are the same today as when this system of molding was first introduced, many refinements in the process have been worked out in recent years. Special attention has been given to the roll-up hinge on which the success of the whole process lies.

At the plant of the McClary Mfg. Co., London, Ont., the hinged match plate system of molding floor work has been developed to an exceptionally high state of perfection. Some of the features of this system, as applied in the McClary shops, will be described in this article. The plant operated by the McClary Mfg. Co. constitutes one of the largest stove manufacturing establishments in Canada. Sixty different styles of stoves and ranges are built and over 1,000 match-plates are in use in the shops.

The foundries produce 30 tons of good stove plate castings per day and two men are constantly employed making match-plates. About two years ago the management commenced to introduce match-plates in the shop

FIG. 1—GRATE BAR MOLD CONTAINING FOUR GRATE BARS MADE WITH A HINGED MATCH-PLATE

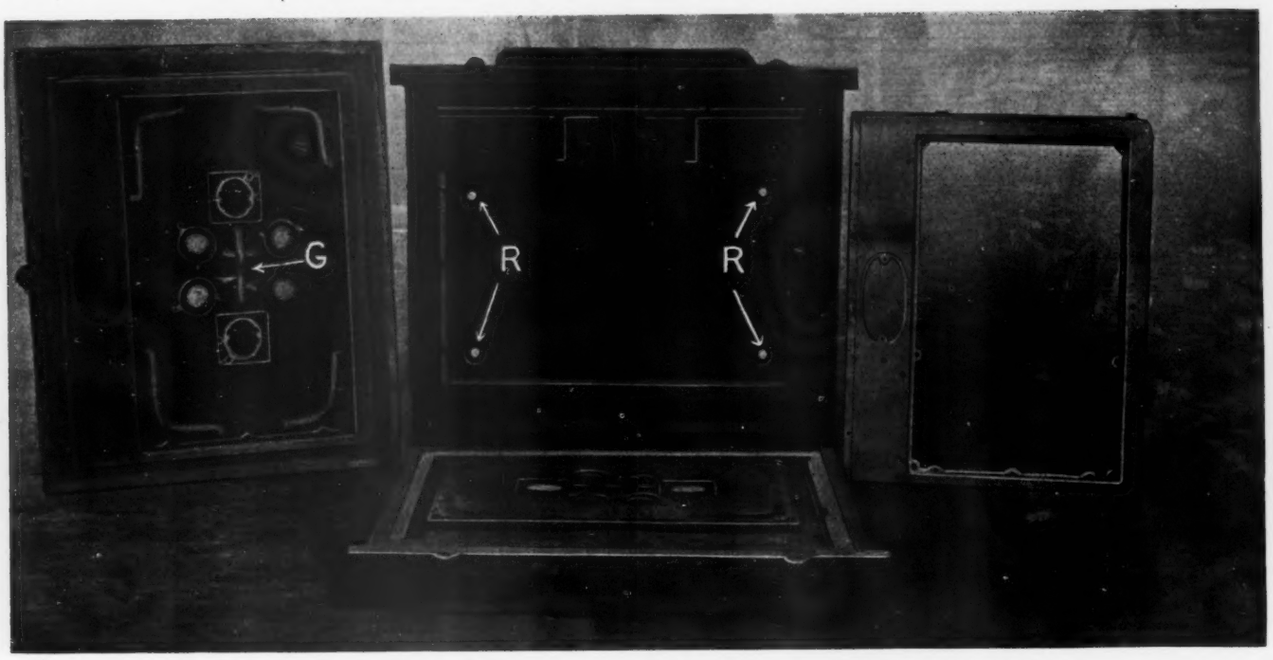

FIG. 2—MOLD FOR A LARGE RANGE TOP MADE WITH A HINGED MATCH-PLATE

with the object of eventually doing all molding by mechanical means with unskilled labor, practically dispensing with journeymen molders. On account of the great variety of the output of the plant, it has been found desirable to run the work in mixed floors and although this militates against the greatest possible output per man per day, good results have been obtained and some surprising economies in molding time have been effected.

Although the equipment used has effected great economies, it is of a comparatively inexpensive nature. Wooden flasks, especially strengthened, are used, together with simple aluminum match-plates, and these constitute practically all of the special equipment employed. On floor work, when using the hinged flasks and match-plate, the number of operations required to make a mold has been reduced 20 per cent and the time required to put up a single mold, 19 x 23 inches in size, has been cut from 18 or 20 minutes to 10 minutes.

Flask and Match-Plate Hinge

The flask and match-plate hinge used in this shop have been improved recently and in their latest form are shown in Figs. 1 and 11. These hinges are made in pairs so that they do not have to be specially fitted to each flask and the only machine work required is in grinding down the upright post, *P*, Fig. 11, until the circular part of the hinge, which is fastened to the cope, fits properly. It will be noted from the illustrations that this hinge is so constructed that its adjustment is not affected by the expansion or contraction of the flask and that although no special fitting is required, there is no lost motion. The hinge permits the cope to be rolled into a perpendicular position, where it is held securely without propping. The extremely simple construction of the match-plate portion of the hinge is one of the special features of this device. The necessity for casting special hinges into each match-plate, together with consequent machining and fitting, is entirely obviated. In the drag portion of the hinge bracket, just in front of the main flask hinges, there are two semi-cylindrical recesses, *R*, Fig. 1, which form the seats for the plate hinges. The construction of the latter is clearly shown in Fig. 11. The plates are cast with two simple lugs or ears on the back corners, to which short lengths of half-round brass rods are screwed, as shown at *S*, Fig. 11. The corners of the lugs on the opposite sides are also rounded off, forming a cylindrical hinge which fits in the seats as indicated in Fig. 1. The brass rods engage the inner ends of the hinge seats and prevent any lateral motion, while at the same time the plate may be instantly removed and replaced without disturbing any adjustments. The hinge requires no adjustment except that on deep molds, such as the one shown in Fig. 11, the lugs are carried back a sufficient distance to give the proper draft to the plate.

FIG. 3—BOX STOVE DOORS IN A 16 X 26-INCH FLASK

FIG. 4—MOLDING MACHINE USED FOR SNAP FLASK WORK WITH A FLOOR OF MOLDS IN THE FOREGROUND

With this form of plate hinge, no lugs with holes engaging pins in the drag are necessary, as in the case of the old hinges, which are shown in Figs. 5 and 7. The new form of hinge is just as suitable for irregular-shaped plates and cut flasks as it is for flasks with straight partings. Fig. 9 shows a plate adapted for use in a cut flask fitted with the improved hinges. If it is desirable to have the cope lift from the drag in a vertical direction for a few inches, the hinge may be upset; that is, its axis is raised above the line of parting between the cope and drag.

The Flasks

Wooden flasks of extra heavy construction are used. The flask, shown in Fig. 1, is 19 x 23 inches and is built of 1½-inch yellow pine or fir. The joints instead of being nailed are halved together, this form of construction being very stiff. In order to make the flask still more rigid, the sides are extended and stiffening blocks are nailed in the corners thus formed, as shown at *B*, Fig. 1.

Grate bars are molded with a hinged match-plate in a 19 x 23-inch flask in the manner illustrated in Fig. 1, there being four bars in each mold. Formerly these molds were made on a molding machine, but it was found that better time could be made on this particular job by molding it on the floor in the manner shown in the illustration. These molds are made by an unskilled man in an average time of ten minutes each.

Fig. 2 shows one of the most difficult plates molded in this shop, this being a large range top, measuring 32 x 38 inches. These plates must be accurate in size and are permitted to deviate only very slightly from a true plane because the whole surface is ground and polished. The hinged match-plate has been found so accurate in operation that very few of these castings are now lost. The mold is poured through four runners, *R*, Fig. 2, there being one at each corner. The nature of the gates is clearly shown on the match-plate which appears at the left of the mold. The finished casting is shown at the right, Fig. 2. This mold is now being made with a small deadhead in the center. The latter is cast with one sprue and is gated as shown at *G*. The management of the plant has found that deadheads interfere with the speed of production and as fast as possible they are being eliminated. The castings formerly made in this manner are molded in separate flasks by men who have become exceptionally skilled in making these sections.

Facing Used

In order to produce a clean casting, which is smooth, true and free from blemishes and to avoid a large amount of printing-back, a special facing has been devised. This is a one-bag mixture consisting of ordinary plumbago mixed with fine parting sand. It is

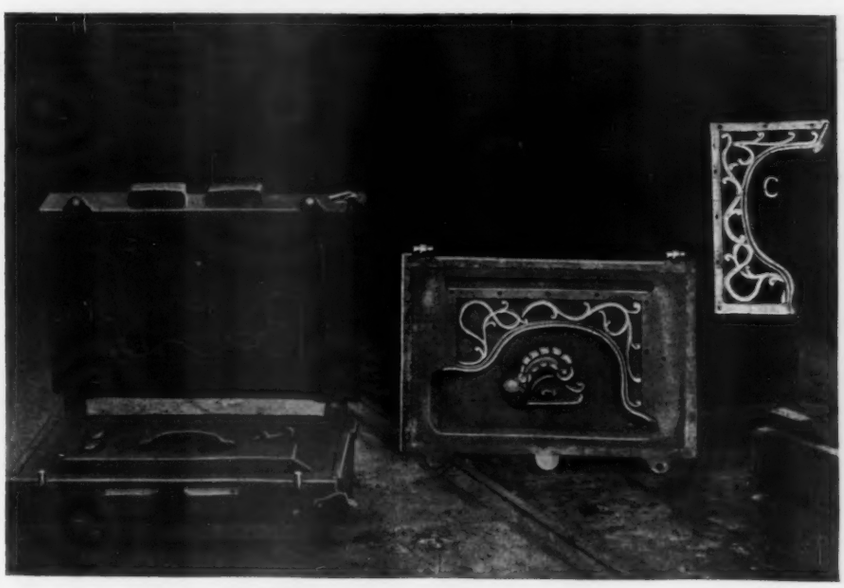

FIG. 5—A FLOOR OF SNAP FLASK WORK, SHOWING ONE OF THE MATCH-PLATES EQUIPPED WITH OLD STYLE HINGES

FIG. 6—A COMPLICATED MOLD MADE BY THE USE OF A HINGED MATCH-PLATE

dusted on the plate before the sand is shoveled into the flask. It has generally been found that it is not necessary to print-back.

Fig. 3 shows two box-stove doors in a 16 x 26-inch flask. Each mold has a separate runner and riser. The match-plate used in the production of this mold is shown at the right in Fig. 3, and one of the finished castings is at the left. In setting-up this work it has been found desirable to print-back in order to neatly reproduce the scroll-work on the pattern.

Snap Flask Work

A floor of snap flask work, together with one of the snap flasks and match-plates is shown in Fig. 5. Snap flasks are used in this shop wherever possible in order to reduce the amount of equipment required, but have been found applicable only to open castings such as the one shown at *C*, Fig. 5, where the outward pressure on the mold is limited. There must also be some center contacts to support the cope. These molds are held together with a skeleton frame and clamp supplied by the Graf Molding Device Co., Louisville, and no weights are used. Steel bands, as shown in Fig. 5, are used to prevent runouts. The molds are rolled up and handled exactly like tight flask molds, except that the flask is unsnapped and removed when the mold is completed. The casting shown in Fig. 5 is a high closet-bracket, together with a back guard corner bracket, which is deadheaded. The flask is 16 x 25 inches.

The draft fronts shown in Fig. 6 are molded in 18½ x 25½-inch flasks, and although these molds are rather difficult to make they are put up by an unskilled man, after some practice, at the rate of six per hour. The mold has two sprues, *S*, Fig. 6, each of which communicates with the casting through five gates, as shown on the match-plate in the background.

Fig. 11 is a water pan for a furnace and on account of the depth of the mold the plate hinges are set back some distance. By the use of the hinged match-plate, the price per piece for this mold has been reduced from 16 to 10½ cents.

A wall register frame, 8 x 12 inches in size, is shown in Fig. 7, there being two patterns on this plate. This mold now pays 11 cents where formerly, when molded by the old method, the rate was 20 cents. Special attention is directed to the feather edges shown on this plate; these are produced accurately and without loss. The method of gating this mold with two sprues and H-gates is shown clearly in the illustration.

FIG. 7—MATCH-PLATE CONTAINING TWO WALL REGISTER FRAMES

FIG. 8—MATCH-PLATE CONTAINING TWO CLOSET BRACKETS AND TWO TEAPOT STAND HOLDERS

Molding Miscellaneous Plates

Fig. 8 shows a high closet bracket and a teapot stand holder molded in a deadhead. This mold is 24 x 25 inches and the price per piece is now 12 cents, whereas it was formerly 21 cents. A wood extension front with two patterns on a plate is shown in Fig. 9. This is an irregular-shaped plate and is molded in a cut flask, 16 x 24 inches in size. In spite of its rather awkward shape it has been found that a man can easily earn a good day's wages at a piece price of 6 cents, using the match-plate shown in Fig. 9. Under the old method the piece rate was 12½ cents.

Fig. 10 shows an air-tight stove top molded in a 20½ x 27½-inch flask. The plate is shown at the left and the finished casting at the right. This job is now molded in 10 minutes by an unskilled laborer. Special attention is directed to the method of gating this pattern. One runner extends down to the center of the pipe collar, where it connects with the casting through four gates, *G*. Another runner connects with the circular gating arrangement shown at *M*. These gates are so formed that they may be removed from the casting with a light blow of the hammer.

FIG. 10—MATCH-PLATE FOR AIR-TIGHT STOVE TOP, SHOWING THE METHOD OF GATING; THE CASTING IS AT THE RIGHT

Molding Machine Work

Some of the lighter work in this shop is molded on machines and Fig. 4 shows a modern machine equipped for the production of fire-door linings. One man puts up 160 of these molds per day, each one being 14 x 16 inches in size. At the extreme left in Fig. 4 is shown a 7 x 12-inch register face, which is molded in a 14 x 18-inch flask on a machine at the rate of 145 per day. The riddle holder, *H*, Fig. 4, has proved to be a great convenience to the molder. The general convenience and handy arrangement of the molders' booth are clearly shown.

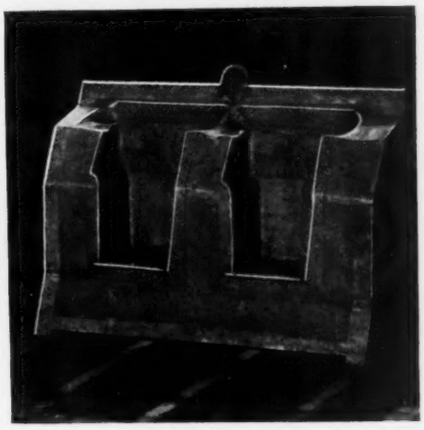

FIG. 9—MATCH-PLATE CONTAINING TWO EXTENSION FRONTS

Annual Bonus

In order to encourage steady work, the McClary Mfg. Co. pays to each man who has been in its employ for a year continuously, a lump sum equal to 5 per cent of his earnings for that year and during the second year increases his piece rate by 5 per cent. In order to further encourage competent men to stay with the company, an extensive lunch room has been fitted up at considerable expense, where lunches are served at absolute cost. The men can take advantage of this convenience or not as they choose. They may bring the main portion of their lunch, supplementing it by hot soup, tea or coffee obtained at the lunch room, or may get a complete lunch at the plant.

Making Match-Plates

When making match-plates, the patterns to be plated are put in flasks large enough to allow 6 inches of sand all around the outside. In making the plate the mold is rammed in the same manner as when an ordinary casting is to be made. After it is completed a skeleton frame, which is cut to conform to the outline of the plate is placed around the pattern while the latter is in the mold This frame is of the same thickness as the desired thickness of the match-plate, generally ¼ inch. After the frame is in place, four strips of wood of the same thickness are nailed on the edges of the flask and the opening between these pieces of wood and the frame is filled with sand and struck off with a straight edge. The frame and pattern are then withdrawn from the mold and the latter is gated in the usual manner. The cope is then replaced and the plate is ready for pouring. By this process it will be seen that the cope and drag are separated by an amount equal to the thickness of the plate. The plates are made of a mixture consisting of five parts aluminum, one part zinc and one-half part bismuth. The aluminum and zinc are melted first and the bismuth is added to the molten mixture.

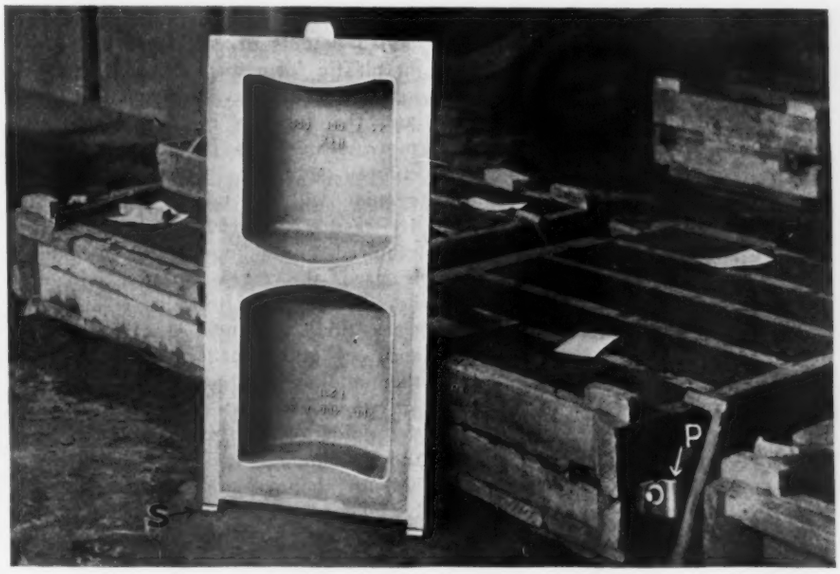

FIG. 11—A PLATE CONTAINING TWO DEEP PATTERNS; THE DETAILS OF THE NEW HINGE ALSO ARE SHOWN

THE AMERICAN PLATER

Hot Cyanide Copper Solution

By Seymour W Rowsbar

AMONG the most useful solutions used in plating plants are the cyanide copper and brass. Nearly every plant, large or small, has a copper solution for one purpose or another. A large number of plants are still using the cold solution, although the advantages of the hot solution are apparent. Many platers make a copper solution according to a certain formula and expect perfect results on all classes of work and under all conditions. This is a big mistake. Usually, a hot copper solution is operated at 10 degrees Baume with sufficient free cyanide to keep the anodes clean. Such a bath will produce beautiful deposits on sheet metal, wrought iron or forged steel, but we do not advise the use of such a concentrated bath when plating cast iron, lead or any of the softer metals.

Hot Copper Bath

It is really wonderful what can be accomplished in a hot cyanide copper bath with a density of only 2 degrees Baume. Gray iron castings may be given a deposit of several hours' duration using a moderate current, and finish perfectly. A firm building gas engines nickel plated the cylinders over a heavy coat of copper. The cylinders first were plated in a cold cyanide bath and then in an acid bath. The bath was operated at 11 degrees Baume and usually 6 volts was used. The work blistered badly; metal and cyanide were added in different proportions with no better results, until finally the bath was at 15 degrees Baume. After reducing the density of the bath to 5 degrees Baume, and placing a steam coil in the tank, the blistering ceased and the cylinders were finished in splendid condition by the use of 4 volts. In the average shop the work is not confined to one line and the solution which will meet every emergency is the most valuable. A low density, hot copper solution fills the bill as far as copper deposits are concerned. The frequent use of bisulphite of soda is very often productive of troubles, the cause of which are blamed on almost anything except the soda. In fact, if the addition of carbonate of copper is not too frequent and electrolytic copper anodes used exclusively, the use of bisulphite of soda may be dispensed with entirely. The occasional use of carbonate of soda will prove beneficial and reduce the amount of cyanide of potassium necessary to keep the bath normal.

Low Copper Solution

A low density copper solution will *throw* better than a solution of 10 to 15 degrees Baume. Articles which have projections and hollows, or deep indentations, may be uniformly plated in a hot cyanide bath of 2 or 3 degrees Baume without burning or overplating the projections while endeavoring to reach the low spots. Where a copper bath is required to meet the demands of both a strong and heavy deposit, the low density solution is capable of doing the job.

To prepare a good low-density solution, proceed as follows: For a 25-gallon solution begin by dissolving 5 pounds of cyanide of potassium in 10 gallons of cold water; when dissolved add 3 pounds of carbonate of copper in plastic form and stir well. If the cyanide does not dissolve the copper and the solution remains black, add more cyanide to produce an amber-colored solution. Certain grades of cyanide will not take up the carbonate readily; therefore, more may be required, but if good grade of cyanide is used, the extra addition will not be necessary. After the solution is clear, add 3 pounds of carbonate of soda of good quality, stir well and then add about 1 pound of carbonate of copper, or just enough to darken the color of the solution; then add the remaining 15 gallons of water and boil for about 30 minutes; use electrolytic copper anodes and keep the bath at about 2 or 3 degrees specific gravity. When replenishing the bath use a brown, glazed stoneware pitcher or a copper dipper of rather deep pattern; place in the pitcher about one pound of plastic carbonate of copper and fill two-thirds full of water, adding about one pound of cyanide of potassium and stir vigorously. The solution will at once become hot, and if it does not boil over in a few seconds, add a small quantity of cyanide. The pitcher should be held over the tank containing the copper solution so that the mixture will not be wasted. After a few trials the quantities may be judged quite accurately and the solution can be brought to the boiling point without delay. This method enables the plater to replenish the bath at any time and permits him to proceed with the use of the solution immediately.

Method of Adding Cyanide

The usual method of adding cyanide or carbonate makes it easy to add too large a quantity of one or the other, unless one makes his additions entirely by weight. The method here described does not permit an overdose of either and, consequently, the balance of the solution is not disturbed. When additions are made separately, the bath is rendered sick and works irregular for some time, for which reason additions are generally made at the end of the day's work. If for any reason the bath must be allowed to settle after being stirred, a pail of cold water distributed over the surface of the solution will greatly hasten the clearing. A hot cyanide copper solution operated at 10 degrees Baume, free of bisulphite of soda will, if kept properly balanced, produce far better results than a cold bath at any density. We admit that the judicious use of bisulphite of soda will render the deposit softer than can otherwise be obtained, but if the current is properly regulated a low density solution will not require this addition to obtain a soft deposit.

As the deposit is directly proportional to the current flowing through the bath, it is very important that the plater should know the amount

of current that is passing through the solution. Hot copper solutions should not be kept heated above 120 or 150 degrees Fahr. For those who prefer a more concentrated solution, we can recommend the new triple-plating salt, Trisalyt, for uniformity and economy, while the preparation of the bath is very simple. For a bath of 25 gallons use 10 pounds of copper Trisalyt and 25 gallons of cold water. This bath should be used at a temperature of 75 or 80 degrees Fahr., with a voltage of from 3 to 3½, depending on the metal being plated, the distance from the anodes to the work being about 6 inches. The amount of copper Trisalyt may be doubled in order to obtain quicker results. The use of electrolytic copper anodes is also advisable and if they become coated with a heavy, green slime, the addition of cyanide of sodium is required. Owing to the high chemical purity of the salts, the cathode draws more freely from the anode and, therefore, the life of the bath is greatly increased. Any cyanide copper bath may be replenished with copper Trisalyt, the amount required depending on the deplenished condition of the solution.

Copper Carbonate

Copper carbonate is usually employed by the average plater when making a bath or maintaining its metallic strength. Therefore, a few words as to its manufacture may be of value. Dissolve a known quantity of sulphate of copper in hot water in a barrel. Care should be exercised to dissolve all of the sulphate. In another barrel dissolve about 2 pounds of carbonate of soda for every pound of copper sulphate dissolved in the first barrel. The barrel containing copper sulphate should not be more than one-half full at this stage. Then add the soda solution to the copper solution, a small quantity at a time, stirring constantly to facilitate the escape of carbonic acid gas. If too much soda solution is added, the sudden liberation of large quantities of gas will cause the mixture to boil over the top of the barrel. The solution should be used when hot as the precipitate is then dense, settles rapidly and is easily and quickly washed.

When the chemical reaction subsides, no more soda should be added, but the barrel should be filled with clean, hot water, and the contents should be stirred thoroughly and then allowed to settle. The barrel now contains carbonate of copper and sulphate of soda. Syphon off the clear liquid which is of no value and fill the barrel with clean hot water; stir well and allow to settle; then syphon off as before; repeat the washing operation several times, or until no trace of soda remains in the clear liquid; then give a thorough, final washing in clean, cold water. After the water is removed, place the carbonate upon a cloth tacked to a frame, to form a strainer. After a few hours, the surplus water will drain off and the carbonate is ready for use. The carbonate kept for future use may be covered with water in a jar, or, if used within a few weeks, it will remain plastic if kept in covered crock.

Occasionally a plater desires to produce a bright copper deposit, but sodas are treacherous when used as brighteners and require great care to maintain them in just the proper condition. The following produces a deposit of nearly a buffed appearance and may be used in any ordinary cyanide copper solution: Caustic potash, 1 pound, and carbonate of lead, 10 ounces. Dissolve the caustic potash in about 6 quarts of hot water, then add the carbonate of lead slowly, stirring constantly. If a residue remains after standing, pour off the clear liquid, which is kept as the brightening fluid. When using this liquid, add only a very small quantity to the bath which is stirred while plating a piece of work.

Too much lead solution will produce a dull color, which is sometimes difficult to remedy. From 4½ to 5 volts may be employed and the bath may be operated as hot as desired. If the deposit shows dull spots, a small amount of caustic potash dissolved in water with a small amount of cyanide of potassium, will restore the bath to its normal condition. When using a brightening agent in a copper bath, it is well to remember that, as in all other solutions, a bright deposit is necessarily thinner than a deposit from a bath not containing brightening agents. For really good copper deposits, where durability or protection against corrosion is the primary object, the use of brighteners should be avoided. Some platers occasionally add a quantity of brass solution to the cyanide copper and claim to keep the density of the brass solution always the same without waste and thereby avoid extremes in the color of the copper deposit. An excess of brass solution will result in a very patchy deposit entirely unfit for ornamental purposes. Sheet copper when used as an anode in a hot copper bath is productive of many difficulties. The electrolytic anode will give the best results in any copper bath.

The Sherardizing Process*

By Thomas Liggett Jr

EARLY in this century, the British admiralty started an investigation on case-hardening. Dr. Sherard Cowper-Cowles was doing work along this line and had been trying case-hardening with a great many different substances. One day he procured some zinc dust. He carried out the case-hardening operation at a temperature less than 788 degrees Fahr., or the melting point of zinc; after the material and zinc dust had become cool he took the material out and found that it had a zinc coating. This was something entirely new, in other words, a piece of steel taking a zinc coat at a temperature below the melting point of zinc. After very thorough and exhaustive tests, it was found that this coating gave the underlying metal better protection from corrosion than the well known hot or electro-galvanizing. The process was called sherardizing, the term being derived from Dr. Cowle's given name.

The apparatus necessary to install a sherardizing plant is very flexible; by this I mean the plants are built to treat different classes of material. For instance, a plant designed for bolts, nuts, small castings, etc., would not be suitable for pipe. The essential apparatus necessary for a sherardizing plant is an oven large enough to receive retorts, and these retorts are built to receive the material intended in the most economical manner. The largest retorts in use today have been installed by the Mark Mfg. Co., of Chicago. They are 26 inches in diameter and 23 feet long and are designed for merchant pipe. Some of the licensees have rectangular boxes. These are used for sheets and metal lath. The number of drums or retorts which are used at one time depends on the daily requirements, and the ovens are built accordingly. The retorts are loaded with material and zinc dust or dross and run into the oven, and heat is applied. Any of the common fuels will answer. The only thing to be sure of is that the oven has a uniform temperature. The

*Presented before the Philadelphia Foundrymen's Association.

retorts are left in the oven for a certain length of time at a constant temperature and then removed. When they can be handled, they are opened and the material and dust are dumped on a screen or grating. The dust falls through and is ready to be used again and the material is finished, being covered with a continuous, uniform coating of zinc iron alloy, with a very thin layer of metallic zinc on the surface. No matter how irregular is the shape of the material, it has a uniform coating and everything is reproduced, which is not the case in either electro or hot galvanizing. In electro-galvanizing the hollow places are not coated, and with hot galvanizing, threads or hollows are filled and flaws are covered.

Zinc Dust Used

The zinc dust which is used in the process is a secondary product from a zinc smelter and is recovered in the flues. The dust is composed of from 85 to 92 per cent metallic zinc, about 7 per cent zinc oxide and some other impurities which are not in sufficient quantities to work any injury. Zinc dross also can be used instead of dust and it has its advantages. It is the material which settles to the bottom of a galvanizing kettle. After treating it, no difficulty is found in pulverizing it so that it can be used.

To date there have been several theories advanced as to the action which takes place in the drums during the process. Some authorities in England and a well-known authority in this country persist in referring to it as the vapor process. This theory is absolutely without foundation. We do know that zinc and iron, when heated slowly together, have an affinity for each other and some of the authorities claim that this affinity is produced by a very slight magnetic action. However, we are not sure what the action is.

The following facts, however, are known:

If metallic zinc content in the dust is kept constant we will get on same class of materials equal weights of coating, under the same temperature and time of treatment.

Zinc does not begin to deposit until the material has reached the temperature at which magnetic oxide of iron appears.

Iron which oxidizes with difficulty, sherardizes with difficulty.

The coating, as mentioned before, is a true zinc iron alloy. We believe that the magnetic oxide of iron which forms on the material is reduced to metallic iron by the contact of zinc, which alloys with the excess zinc and exactly replaces the film of magnetic oxide first formed.

The continuity of the zinc dust coating, when properly applied, is equal to and in the majority of cases superior to the hot galvanized coating. While it is true, under the microscope the zinc iron alloy shows cracks or fissures; these are of such minute dimensions that nothing can get through to the underlying metal. The adherence of this alloy is very tenacious.

Durability of Coating

The durability of the alloy coating is great, although it is a little more brittle than pure zinc and has a slight tendency to flake if bent through a sharp angle. The metal which is exposed after the flaking is still resistant to corrosion, which shows that the underlying metal is not exposed. The resistance of the alloy to corrosive agencies is much greater than with the zinc coatings. Sherardized, hot galvanized and electro-galvanized articles were subjected to a 20 per cent solution of sulphuric acid. The hot galvanized and sherardized samples had the same weight coating and the electro-galvanized were somewhat lighter. The results of the tests are given herewith:

Coating.	Minutes in H_2SO_4	Weight of coating, ounces per square foot.
Sherardized	70	1.07
Hot galvanized	23	1.07
Electro-galvanized	44	0.62

This shows that while the sherardized coating has more iron in it than the hot galvanized, it will resist corrosion over three times as long as an equal coating of hot galvanizing. Practically the same results have been obtained in England, where it is claimed that one-half ounce of sherardized coating per square foot is equal to 1½ ounces of hot galvanizing. The claim that pure metals are more resistant to corrosion than impure metals is borne out by these tests. The alloy, which is a definite homogeneous compound and pure, in that it behaves as a single metal, is more resistant to corrosion than the hot galvanized coating. The reason for this is that the impurities in the latter are not alloyed together and consequently form local couples.

A metallic coating to be protective must be electro-positive to the underlying metal. While there are several "electro-positive-to-iron" metals, zinc is the only one that it has been found commercially possible to use. Some authorities claim that the more electro-positive a metal is the better protection it gives, but this is disproved, as metallic calcium or sodium are not protective metals, yet are much more electro-positive to iron than is zinc. This galvanic property becomes useful when the coating is broken and the underlying iron is exposed to corrosive agents. The surrounding protective coating becomes the anode and the galvanic current flows from the surface to the exposed iron, which is the cathode. It is this cathodic current which prevents the corrosion of the iron. A coating which protects galvanically does so at its own expense, as the corrosion takes place at the anode. The more electro-positive a metal is the more rapidly it will corrode, as there is more current flowing. Therefore, the nearer the potential of the coating metal is to the underlying iron, the slower will the protective coating be corroded. From this it is evident that the sherardized coating is more resistant to corrosion than either the hot or electro-galvanized, as its potential is about 0.25 volts compared to 0.53 for hot and 0.502 for electro-galvanizing. The appearance of a newly sherardized piece of metal varies from a satin silvery color to that of dull zinc. Owing to the iron in the coating, it often turns yellow after a short exposure. This has been mistaken for rust by some of the highest authorities on corrosion in this country.

Testing Sherardized Material

There has been considerable discussion regarding the proper method of testing sherardized material. The test most frequently used is the Preece or copper sulphate method. This consists of immersing a piece of galvanized material in a standard copper sulphate solution for one minute, then washing in clear water and drying with cotton waste. This is repeated four times and if there are no bright metallic copper deposits, the material is accepted. The standard solution is one whose specific gravity at 65 degrees Fahr. is 1.186. It is prepared by dissolving copper sulphate in water, to which an excess of cupric oxide has been added. This solution is then filtered and the specific gravity made 1.186 at 65 degrees Fahr.

The trouble of testing sherardized material by this method is that if the material is wiped with waste a burnishing action takes place. The reasons for this are that the sherardized coating being an alloy, the copper is deposited more slowly and is more adherent than that which deposits on hot galvanized material; as the sherardized surface is rough it affords a foothold for this copper and the waste rubbing the top burnishes the copper so that instead of cleaning the surface as the specifica-

tions intend, the deposit is rubbed onto the object. With further dipping, the copper deposit thickens, and those not thoroughly familiar with this action will decide that the coating has failed. To overcome this, it is always best to use a stiff bristle brush and scrub lightly instead of using waste.

The alloy coating dissolves slower in the standard copper sulphate solution than either hot or electro galvanizing. It has been found that the sherardized or zinc iron alloy coating loses 0.005 ounces per square foot per dip; hot galvanized, 0.068 ounces per square foot per dip, and electro-galvanized articles 0.067 ounces per square foot per dip. This is another evidence that a sherardized coating will withstand corrosion better than either hot or electro-galvanizing of equal weight.

The sherardizing process is particularly well adapted for treating castings. As previously mentioned, the surface of the casting is exactly reproduced. As the heat is applied slowly and the material is cooled slowly, all strains are relieved and the operation serves to anneal the casting. This, in contrast to the treatment the material is given in the hot process, which crystallizes about 85 per cent of material treated, due to raising the temperature of the castings so suddenly and then cooling at about the same speed.

In summing up the sherardizing process we find it has the following advantages:

As compared with the electro-galvanizing process, cleaned articles do not have to be handled as carefully. The same weight of coating costs about 15 per cent more by the electro process, due to current cost and extra wear on anodes.

The cleaning or pickling is the same as for hot galvanizing, but no flux is used.

A sherardized coating one-third as heavy as hot galvanizing will give the same protection.

There is no great waste of skimmings and dross. It has been found that about 30 per cent of the charge is reduced to this waste, while less than 1 per cent of the dust is lost.

The oven is heated only when using the process, while a galvanizing kettle must be kept hot 24 hours a day.

The sherardized coating, being a true zinc iron alloy and consequently free from local couples, is more resistant to acids and corrosion than the impure spelter found on a hot galvanized article.

The sherardized coating reproduces exactly the articles treated, making recutting of threads unnecessary, while it is necessary to cut off the protective coating to get the threads to fit on the hot galvanized articles.

If either hot or electro-galvanized coating is broken, rust forms and creeps between the zinc and iron, and in a short time destroys the entire coating, while if the sherardized coating is broken, rust forms at the break and no further action takes place.

TROUBLES OF THE ELECTRO-PLATER

Discussed by Practical Men

Difficulties With a Nickel Solution

One tank of nickel solution which we have gives a deposit which I am unable to color. I have tried to fix it, but thus far have been unable to do so. How do you account for this?

Your solution is apparently alkaline. If you use ammonia or replenish the bath with double nickel salts, you will have to beware of alkaline conditions. Carbonate of nickel used to reduce the acidity is safer and single nickel salts will not introduce the ammonium sulphate when not required. The single salts being purely metallic, they are cheaper in the end. When the bath appears to conduct poorly, add 1 ounce of common salt to each gallon and to bring out a silvery tone to the deposit, add 2 ounces of boracic acid to each gallon. The surface should then color very easily. We would also advise looking over the anodes in the tank, possibly some are very hard and have not been giving off metal. Such an anode, after long suspension in a bath, is liable to render the entire bath faulty, the deposit possessing a furry surface. Boil, sand blast or scrape the surface to avoid further annoyance.

Transfer of Ink Prints

I am endeavoring to construct a stencil design by using portions of cartoons and newspaper cuts. I use the stencils in etching on metals and would like to obtain a hint as to how to make a solution which will transfer ink prints.

For your purpose dissolve one bar of common soap in one gallon of water, then add ½ pint of turpentine; stir well and allow to stand 12 hours; after again stirring the solution, bottle immediately, when it will be ready for use.

Wood Polishing Wheel Difficulties

We have considerable trouble with wood polishing wheels. The leather becomes loose and the emery fails to remain in good cutting condition.

When attaching the leather, be sure that both the wood and the leather are at least warm. Use the best glue obtainable and apply only a few inches at a time. Tack one end of the leather and stretch it to the limit. Tack it to the wood with wooden pegs and give the wheel ample time to dry. Never dress wheels with thick glue as it will not permit the emery to form a solid, compact mass. The emery must be embedded in the glue, not merely held at one point. Do not allow the glue to boil, yet it should be used hot and liquid. Glue deteriorates at the boiling point. Wood and leather will not withstand boiling water, consequently it damages the surface of the wheel. If the wheel is cold, the glue will be chilled and will loose its power of penetration. The emery should be kept in cast iron troughs and should be heated to at least the same temperature as the glue, or even hotter. To prevent any failure of the glue adhering because of grease on the surface of the wheel, use a small amount of slacked lime on the wheel before redressing.

Ormulu Gold Finish

We are making castings in slush molds from an alloy containing 90 parts of lead and 10 parts of antimony. We would like to finish them a dead yellow and would like to know how to proceed.

Ormulu gold is the finish to which you refer. Cut down the surface with tripoli or sand buff, as is customary with such an alloy. Strike in a cyanide copper bath, wash and then give a one-half to one hour deposit in an acid bath (copper). Wash again and immerse in boiling water, allowing it to dry and cool. When cold, pass quickly through a slow-acting, acid bright dip, which will produce the dead or ormulu surface. Then give a slight deposit in a bright brass bath to obtain a yellow surface; wash again and gild for about 20 or 30 seconds in a hot gilding solution. Wash and carefully dry by using plater's compound solution, followed by the use of clean cloths or clean boxwood sawdust. If there are high portions to be brightened, they should be burnished by hand; protect the finish by spraying with a transparent lacquer.

Heavy Brass Deposit

We manufacture automobile parts, such as hand brake and gear change levers, steering columns, etc. The levers are forged steel and are brass plated. We have been running the work 1½ to 2 hours, using 3 to 5 volts; the solution is cold and the bath stands 10 degrees Baume; the distance from the anode to the cathods is 10 inches. The deposit is often of various colors and frequently blisters.

To obtain a heavy brass deposit on such parts as you mention, automobile makers, turning out the best plating today, run the work not less than 8 hours with frequent scratch-brushing. The work should matte in from 1 to 1½ hours sufficiently to require the scratch brush. In this manner a very dense, smooth deposit is obtained, requiring only a light buff. Increase the density of the solution to 15 degrees Baume by the addition of zinc and copper carbonates and use 5 volts pressure. The distance from the anode to the work may be reduced safely to 6 inches. The color may be made uniform by adding free cyanide. The absence of free cyanide results in the deposition of several colors on one piece of work. Use the bath slightly warm or about 80 degrees Fahr. The blisters indicate too strong a current. If the blisters form only on the lower portions of the work, a small brass tube or ¼-inch rod, suspended from the cathode rod so as to hang horizontally about 2 inches below the work, will usually prevent the blisters and still allow a suitable current to be used to hasten the deposit.

Cleaning Compound

I am using what is termed rock potash for cleaning work for plating, but it does not act quickly and the work becomes tarnished. How can I obtain better results?

Add from 5 to 10 ounces of common resin to each 50 gallons of solution to assist in cutting the grease; also add 1 ounce of cyanide of potassium, which will prevent the work from tarnishing.

Removing Hard Enamel

We are pleased with your new department for platers and polishers and desire to take advantage of your query column. We have several thousand steel wire rings used as automobile hub cap retainers which are coated with a hard enamel. How can we prepare them for plating?

The cheapest and most effective method to remove the enamel would be to tumble them with steel punchings in a soda ash solution. This will require about five hours; remove and wash thoroughly and finish in leather meal. The entire surface will have a uniform luster. The rings can be plated by the barrel method, using steel balls, or in a still solution on holders and burnished in a ball burnishing barrel, or with leather meal and vienna lime.

French Gold

I would like to obtain Roseleur's formula for a French gold. Where can I get a copy of Roseleur's work on plating?

Roseleur's formula for a light-colored gold, follows: Fine gold converted into chloride of gold, 2½ pennyweights; cyanide of potassium, 2½ pennyweights; phosphate of soda, 8 ounces; bisulphite of soda, 1 ounce, and water, 1 gallon. Use at a temperature of about 180 degrees Fahr with a platinum anode. This formula is known as a salt water gold-coloring solution and should be used accordingly. It produces the best results upon polished copper, as it has a tendency toward brassy tones on lighter colored metals, owing to the bisulphite of soda. The dark copper base lends color to the gold, producing a beautiful effect. You can only hope to obtain Roseleur's book by advertising and by chance finding some one who wishes to sell his copy. The book commands a high figure.

Black Nickel Formula

I desire a black nickel formula which does not require arsenic and which will produce a deposit which can be buffed.

A very reliable formula for black nickeling without the use of arsenic is made as follows: Double nickel salts, 6 ounces; sal-ammoniac, 4 ounces; sulpho-cyanide of potassium, 2 ounces; water, 1 gallon. Prepare the solution by dissolving the chemicals, mixing well, then dissolve ¼ ounce of carbonate of copper in ½ ounce 26 per cent liquid ammonia and add to the solution. This should be thoroughly mixed. Use sheet brass anodes and a current tension of from 2½ to 3 volts. Too much current produces grayish streaks. On a polished surface, the deposit will be a rich, deep black. After black nickeling, buff with a very soft wheel, using a good coloring polish. Then wash in benzine and dry in sawdust or by the use of cloths and lacquer.

Gold Bronze

There are numerous alloys of copper that closely resemble gold, but the most perfect imitations are obtained by alloying copper and aluminum in various proportions. An alloy of copper, 95 per cent, and aluminum, 5 per cent, resembles 18 carat gold; another alloy containing copper, 96 per cent. and aluminum, 4 per cent, is similar in appearance to 14 carat gold. A good imitation gold alloy that does not contain aluminum, consists of copper, 100 pounds, and antimony, 6 pounds. Other alloys that possess a fine gold color follow:

Copper, 95 per cent, and tin, 5 per cent.

Copper, 90.5 per cent; tin, 6.5 per cent, and zinc, 3 per cent

Trade Note

The works of I. S. Spencer's Sons, Inc., Guilford, Conn., are handsomely illustrated in a booklet recently issued. This business was established in 1857 by Isaac Stowe Spencer and his son, Christopher Spencer, and the works are now conducted by the third generation of this family. A large foundry is operated for the manufacture of a varied line of hardware specialties.

The Early History of Copper and Its Alloys*

An Interesting Discussion of the Melting and Molding Devices Used by the Ancients for the Production of Alloy Castings

By W Gowland

THE discovery of metals, and notably the application of copper and its alloys in Neolithic times, formed one of the greatest events in the history of human development, and exceeded in importance all other discoveries, as it constituted the germ from which the civilization and culture of the present has sprung. The order in which the metals became known was not the same in all parts of the world, as the various ores are capriciously distributed. The first metals with which mankind became aquainted were in all probability gold and silver, as these metals occur in a native condition. According to ancient writers, the momentous discovery that metals were contained in ores, was brought about by means of a great conflagation, which consumed forests covering the outcrop of metalliferous veins, reducing the metals and bringing them to the notice of man, but there are no grounds for such inference. The discovery of metals had a more commonplace and humble origin, in the domestic fires of that by-gone age.

The extraction of metals from their ores is comparatively easy, and the pieces of ore forming the ring of stones that enclosed the domestic fire, would become reduced to metal if accidentally embedded in the embers. The camp fire was thus the first metallurgical furnace, and from it, by successive modifications, the huge furnaces of the present day have been gradually evolved. The first furnaces were simply shallow cavities in the hearth of the fire, and this cavity became gradually larger, by digging it deeper, or surrounding it with a wall of stones. In England, furnaces of this primitive description survived up to the 17th century and at the present time the furnaces for melting copper, tin and lead ores still extensively employed in Japan, are mere holes in the ground as simple and rude as the means employed in the Bronze Age.

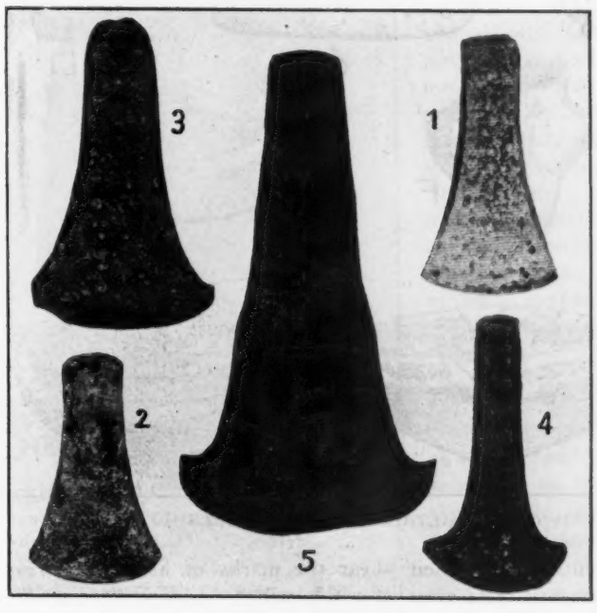

FIG. 1—TYPES OF FLAT BRONZE AXES IN THE COLLECTION OF THE BRITISH MUSEUM

FIG. 2—TYPICAL EXAMPLES OF COPPER CELTS IN THE COLLECTION OF THE BRITISH MUSEUM

Early Alloys Made by Direct Process

The early alloys of copper were obtained by the reduction of copper and tin ores which were smelted together and formed the alloy. As it has been claimed by archaeologists that alloys cannot be made in this manner as the tin would pass into the slag instead of into the copper, the writer made experiments which completely disprove these theories. The furnace used was a hole in the ground and the fuel, charcoal. A mixture of green carbonate and tin-stone was smelted in the furnace and an alloy of copper and tin containing 22 per cent of the latter was formed. The experiment was repeated several times with the same result, and proved beyond dispute that when copper and tin ores are smelted together as in primitive times, bronze is formed. In various parts of Great Britain and other countries, *founders' hoards* have been unearthed, consisting of worn out and broken copper implements, waste castings, and rough lumps of copper, apparently gathered for recasting. The shape and structure of these pieces of metal indicate the manner in which they were formed, by the reduction of the ores with charcoal in a furnace formed of a small shallow hole scoped in the earth and about 10 or 12 inches in diameter. The ore and charcoal were placed alternately in layers, and the fire was probably urged by some form

*Abstract of the presidential address presented at the general meeting of the Institute of Metals.

of bellows. When the charge was melted, the slag was raked off, and the metal was allowed to solidify, but while still soft, was broken into small pieces convenient for use. The production of alloys in the early part of the Bronze Age was accomplished by smelting ores of copper containing tin, and the percentage of tin in the resulting metal varied with the percentage of cassiterite in the ore, and the regularity with which the smelting operations were performed. Consequently, the implements and weapons are of varied composition, and range from 3 per cent of tin upwards.

The presence of antimony is a curious feature of the early weapons of Hungary. This composition was doubtless due to the production of the alloys from the antimonial ores of that country. One sample of bronze analyzed by Dr. Helm had the following composition: Copper, 91.12 per cent; antimony, 4.48 per cent; tin, 0.78 per cent; nickel, 0.61 per cent; arsenic, 0.61 per cent; lead, 1.63 per cent; silver, 0.45 per cent; iron, 0.49 per cent, and sulphur, 0.12 per cent. Axes made of this alloy would be fairly serviceable on account of the hardening influence of the antimony and they were used, with antimony largely replacing tin, until late in the Bronze Age. A comparison of the analyses of a large number of primitive alloys does not support the statement that has been frequently made, that such alloys consisted largely of copper and tin in the proportions of nine of copper to one of tin. In 57 analyses of early weapons and implements, the tin content ranged from 3 to 13 per cent and in 15 analyses of socketed axes and palstraves, from 4.3 to 18.3 per cent; in spear and lance heads, from 11.3 to 15.7 per cent, and in swords of a later date, the tin content ranged from 9 to 18 per cent It is worthy of note that the proportions of tin in each alloy bear a surprising relation to the uses to which the metal was put, showing that the workers of the later Bronze Age deserved great credit for their knowledge of metallurgy. The difficulties the early workers had to contend with were great, for it is self-evident that alloys of definite composition could not be insured by the practice of smelting mixtures of ores. It would seem, therefore, that when we find weapons or implements of a composition suitable for their intended use, some physical tests must have been applied to the furnace product before it had been used in their manufacture. Some typical examples of flat bronze axes in the British museum are shown in Fig. 1. Each of these were analyzed by the writer and their composition is given in Table I.

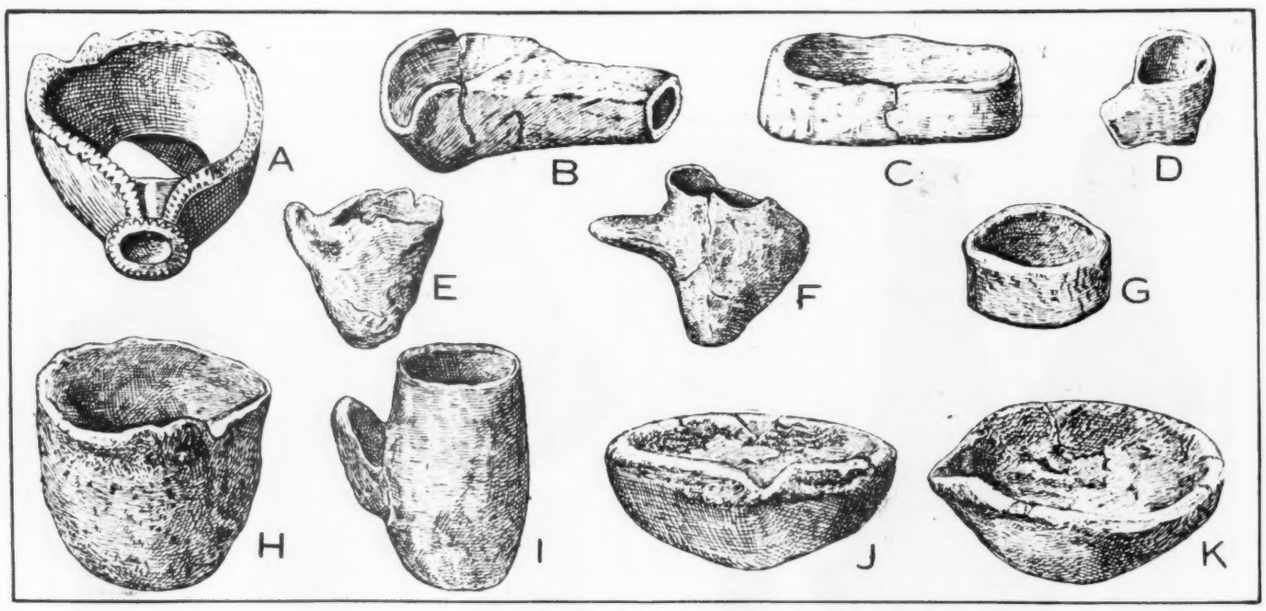

FIG. 3—PRE-HISTORIC CLAY CRUCIBLES AND OTHER METALLURGICAL VESSELS

Methods of Manufacture

We will now pass on to a brief consideration of the methods followed by prehistoric man for the manufacture of his weapons and implements. Practically all copper celts, Fig. 2, were cast in open molds, for if cast in closed molds they would be more or less vesicular and worthless, except when the copper contained arsenic, tin, antimony, zinc or nickel in not less proportions than 1 per cent, or an excess of cuprous oxide. The remains of the appliances which have been found show clearly that the metal from the smelting operation was remelted in crucibles and poured from them into molds of clay or stone, Fig. 4, perhaps of sand, but of this there is no definite evidence. The metal was not ladled from the smelting furnace, as the small crucibles with rude handles which have occasionally been found, and have been erroneously supposed to be ladles, show no signs of having been exposed to a high temperature both on the inside and outside, as would have been the case had they been used as ladles; the interior and upper edges alone bear the marks of heat. The reason for this will be explained later.

Implements and weapons of bronze, unlike those of copper, were always cast in closed molds. The method of melting the metal in each case was as follows: The furnace or hearth was merely a shallow depression in the ground. The crucibles were made of clay, which was sometimes mixed with finely cut straw or grass. They were embedded in the ashes at the bottom of the hearth in such a manner that their faces and sides were thoroughly protected from the intense heat of the fire, their upper edges and interior only being exposed. This method had been adopted owing to the fusible character of the clay of which they had been made. The fuel used was wood and the

charcoal produced during the process. The crucible having been placed in position, was charged with copper, copper and tin-stone or copper and tin, and the fire was built over the charge. A sufficiently high temperature for melting the metal could be obtained by the wind alone. When the contents of the crucible were melted, it was removed from the furnace, and the metal was poured into a mold. In consequence of this mode of heating, the lower parts of the crucible, it is evident, will bear but slight traces of the action of a high temperature, while the upper edges and the interior will exhibit a fused or semi-fused structure, and this is precisely what we find in all early crucibles.

In Fig. 3 are illustrated some of the most important types of crucibles. The small capacity of the greater number of crucibles that have been

FIG. 4—A STONE AXE HEAD MOLD FOUND AT EL ARGAR

found, is worthy of note. Few can have held more metal than would suffice for a single axe. This is, however, not surprising, if we remember that they were the appliances of that remote time when metallic weapons were only beginning to replace those of stone. The clay vessel, *A*, Fig. 3, was found among the debris of dwellings in Carnolia. It is open to doubt whether it is a crucible or not. Types such as *B* have been found in Switzerland and Ireland. They are a common form of primitive crucible and are furnished with a socket for the insertion of a stick by means of which they were removed from the fire and the contents poured into the mold; *C* shows a shallow, oval dish of somewhat rare occurrence. These dishes probably were employed in a rude refining process, which consisted in skimming the surface of the metal to allow the air to act and oxidize some of the impurities out of the crude copper; *D* was found in Lough Mourne, Ireland; *E, F, G, H* and *I* show crucibles found at Dunadd, Scotland; *J* and *K* were found with copper and bronze implements and stone molds in Mercia and Almeria in Spain.

The Use of Stone for Molds

The molds used by primative man are also of considerable interest. The earliest known are open molds and consist merely of cavities of the necessary form and size, hollowed in the surface of a stone. Fig. 4 is a characteristic example. The molds of the later Bronze Age were either made of clay or bronze, an excellent example of the latter type being shown in Fig. 6. In casting swords and daggers in bronze, the molds must have been of clay, and were undoubtedly heated to dull redness, just before receiving the metal. This method of making castings is still practiced in Japan, and in no other manner could such perfect castings of their thin blades have been obtained. The castings, generally, were hammered at their cutting edges, and it is to this hammering, and to it only, that the hardness of the cutting edges of both copper and bronze weapons is due, and not to any method of tempering.

The Lost Art of Tempering Bronze

Much has been written about the so-called art of tempering bronze supposed to have been practiced in those times, and the hardness of the metal has been claimed to be greater than can be produced at the present day. Those making this assertion never could have made practical tests of the hardness of bronze. It they had made any experiments it would have been found that the ordinary bronze of today can be made as hard, or harder than that of prehistoric times, by hammering alone. Until the introduction of iron, copper and bronze played an important part in the lives and struggles of the early races inhabiting the Grecian Archipelago and at a later period, bronze afforded an imperishable material to the great sculptors of the golden age of Greece, by which many of their incomparable works have been preserved. There are no records in Greek literature of metallurgical processes, as in the writings of the Romans, but the remains of ancient furnaces for smelting lead ores have been found from time to time, which indicate that the low hearths of the Bronze Age were employed, and reasoning from Japanese metallurgical procedure, similar furnaces would be used for copper. The island of Cyprus was once rich in copper ores, and was doubtless the source from which the early Greeks obtained their copper.

Some of the earliest specimens of copper found in Greece, are some nails obtained by Dr. Schliemann at Orchomenos, a city in Boeotia, which was in a state of decay in the time of Homer. These nails belong to that remote period in Mediterranean civilization to which the name Mycenaean has been applied. One of these nails analyzed by Rammelsberg had the following composition: Copper, 99.53 per cent; lead, 0.27 per cent; iron, 0.20 per cent.

FIG. 5—A ROMAN CAKE OF COPPER FOUND AT AMLWCH, ANGLESEA, WALES

Two very large nails of about the same date, one weighing 2½ pounds, which were found by Schliemann with some carbonized beams in his excavations in the second city on the site of Troy, were analyzed by Schroeter with the following results: Copper, 99.55 per cent, and copper, 98.65 per cent, iron, 0.85 per cent, and tin, 0.45 per cent. They are interesting as showing that the men of that remote period were able to produce copper to tolerable purity, but this would not be difficult, as the ores which they worked would be oxidized ores, oxides and carbonates from the outcrops of veins, namely, the parts which were exposed at the surface of the ground. Bronze was also then

FIG. 6—THE TWO HALVES OF A BRONZE MOLD; THE CASTING MADE FROM THE MOLD IS IN THE CENTER

in use for nails in building construction, but especially for weapons, and was of good quality, one of the weapons consisting of copper, 90.76 per cent; tin, 8.42 per cent; lead, 0.32 per cent, and iron, 0.54 per cent.

Art Bronzes First Made in Egypt

There is abundant evidence to show that Egypt was the first in the field in artistic bronze casting. When it first began it is difficult to say, but objects of at least as early as 3000 B. C. are in existence. Even in the early examples, great technical skill is displayed. The most ancient Greek bronzes are solid castings, whereas in Egypt they are light and hollow, having been cast with a core of argillaceous sand, which still remains in many specimens. In Table II are given a number of analyses of ancient statuary bronzes some of which contain comparatively large amounts of lead and very little tin, and the question naturally suggests itself whether this was due to the scarcity of the latter metal. Only a few analyses have been made and unfortunately few of the objects can have even approximate dates assigned to them. Bronze was in extensive use in Nineveh about 1000 B. C. for vessels and utensils of many kinds. In the British Museum there is a large collection of these objects obtained by Mr. Layard while excavating in the ruins of Nineveh.

Several analyses have been made by Fellenberg, of which the following is representative: Copper, 86.84 per cent; tin, 12.70 per cent; lead, 0.28 per cent; iron, trace, and nickel, 0.18 per cent. The content of tin in another object was considerably higher, the mixture containing the following: Copper, 80.84 per cent; tin, 18.37 per cent; lead, 0.43 per cent, iron, 0.16 per cent, and nickel, 0.20 per cent. One of the objects discovered consisted of bronze cast over an iron core. The bells of this period that have been discovered, contain 14 per cent of tin, showing that the Assyrians were well aware of the effect produced by changing the proportions of the metals.

Nickel in Greek Copper

A curious feature of Greek copper coins of a later period, is the presence of nickel, which varies from traces up to 0.5 per cent. The percentage of tin is somewhat irregular, but in most examples ranges from 8 to 11 per cent. The same is true of the Macedonian alloys made during the period from the third to the second century B. C., but in this case the percentage of tin is higher and varies from 10 to 12 per cent. These alloys were undoubtedly made by melting copper and adding tin, and not as in the Bronze Age, by smelting stanniferous copper ores, or by melting copper with tin ore.

Table II.

ANALYSIS OF ANCIENT STATUARY BRONZE.

	Copper, per cent.	Tin, per cent.	Lead, per cent.	Iron, per cent.	Zinc, per cent.	Nickel, per cent.	Antimony, per cent.	Arsenic, per cent.	Analyst.
Ancient statuette with core inside.	85.06	2.75	10.89	0.71	...	0.40	0.37	...	Fellenberg.
Fragment of a large statue.....	81.22	2.51	16.00	Trace	...	0.25	0.02	...	Bibra.
Statuette Osiris (300 to 200 B. C.), with core.	76.83	11.23	11.70	Trace	...	....	0.13	0.11	Bibra.
Plate from a mummy case (300 to 200 B. C.)..	75.24	13.15	11.40	Trace	...	0.21	....	....	Bibra.

Table I.

BRONZE FLAT AXES, BRITISH MUSEUM.

Locality, where found.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Iron, per cent.	Nickel, per cent.	Arsenic, per cent.	Antimony, per cent.	Silver, per cent.	Sulphur.
Taxley Fen, Huntingdonshire	89.72	8.99	Trace	0.16	0.11	0.68	0.15	0.09	Nil.
Yorkshire (Butterwick).	87.97	10 74	Trace	0.10	0.06	0.56	0.15	0.16	.....
Cambridgeshire	87.41	11.04	Trace	1.22	0.11	Trace	Nil.	Trace	.....
Plumpton Plain, near Lewes	86.79	11.34	Trace	0.14	0.37	0.78	0 31	0.17	Manganese, trace
New York	85.83	11.73	1.21	0.10	0.14	Nil.	Nil.	Trace	.....
Ireland	86.20	12.52	Trace	0.19	Nil.	0.68	0.26	0.21	.....

Superiority of Macedonian Coin Alloys

The Macedonian coin alloys are the best of the ancient bronzes, as shown by the following analyses made by Bibra: Copper, 87.72 per cent; tin, 11.70 per cent; iron, 0.27 per cent; nickel, 0.38 per cent, and copper, 88.56 per cent; tin, 10.31 per cent; lead, 0.73 per cent, and nickel, 0.40 per cent.

The statements of Pliny as to the composition and method of manufacture of the bronzes in Rome, are for the most part useless and misleading.

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

FORMULAS FOR THE BRASS FOUNDRYMEN.

Fusible Alloys.

Alloys having low melting points find many industrial applications, being used as solders, for making fuse wire, fusible safety boiler plugs, for the measurement of temperatures, as hardening baths for steel and for the reproduction of medals. This class of alloys is composed of lead and tin in varying proportions, with the addition of small percentages of bismuth or cadmium to increase the fusibility of the metal. The composition and melting points of a number of fusible alloys are given in the following table:

Tin, per cent.	Lead, per cent.	Cadmium, per cent	Bismuth, per cent	Melting point, degrees Fahr.
25.00	75.00	0	0	482
34.00	66.00	0	0	441
40.00	60.00	0	0	412
50.00	50.00	0	0	370
60.00	40.00	0	0	334
66.00	34.00	0	0	340
43.50	43.50	0	13.00	311
40.00	40.00	0	20.00	283
34.00	33.00	0	33.00	258
20.00	30.00	0	50.00	212
18.75	31.25	0	50.00	208
25.00	25.00	0	50.00	200
12.50	25.00	12.50	50.00	140
26.60	13.40	10.00	50.00	100

Pure Banca tin is used by the United States government for making fusible safety plugs for boilers. The melting point of these alloys can be ascertained by suspending a sample of the metal on a wire in a bath of water or melted wax, in which a thermometer is immersed. The heat of the bath is increased gradually until the alloy melts, the temperature being indicated by the thermometer. Water only can be used for alloys melting below 212 degrees Fahr. Beyond this point the use of wax is necessary.

USEFUL FORMULAS FOR THE FOUNDRYMAN.

Temperature Measurements.

According to several authorities, the temperature of a heated body can be judged approximately by the eye, by the amount of light emitted when viewed in the dark, and the following table has been compiled to assist in gaging temperatures where greater accuracy is not required, or where more precise methods are not available:

Appearance of heated body	Temperature, degrees Fahr.
Faint red	878
Dull blood red	990
Full blood red	1,050
Dull cherry red	1,195
Full cherry red	1,375
Light cherry red	1,550
Deep orange	1,640
Light orange	1,730
Yellow	1,832
Light yellow	1,976
White	2,200
Bright white	2,550
Dazzling white	2,730

A convenient method of ascertaining the temperature of furnaces is afforded by the use of Segar cones, which are small pyramids of clay, about 3 inches in height and having 5/8-inch base. These cones are graduated to fuse at temperatures ranging from 1,094 to 3,470 degrees Fahr., and are numbered from 0.022 to 39. When the fusing point of the cone is reached, the top bends over until it touches the surface on which it rests.

With reference to the Corinthian bronze, the beauty of which has been so extolled by classical writers, Pliny states that the alloy was discovered by the Romans at the sack of Corinth, when vessels of gold, silver and bronze had been accidentally melted together during the burning of the city and had produced a golden bronze. The siege of Corinth, however, occurred in 146 B. C., but the excellence of Corinthian bronze had been recognized long before that date. Whatever may have been the exact composition of this alloy, no addition of gold or silver to any copper-tin alloy will cause it to closely resemble gold. Imagination is probably responsible for the accounts given of this bronze by ancient writers, especially when we read also that its beauty was derived from being cooled in the water of the fountain of Peirene. Unfortunately, but few analyses have been made of Greek bronzes, and these are included in Table III. With the fall of Greece and the rise of Rome, an important period was commenced in the history of copper and its alloys. Copper smelting was vigorously carried on in Spain and Britain, by the Romans, and in Rome, the use of bronze was greatly extended. Of special importance was the invention of the alloy, brass,' which came into use for the first time in Europe.

Table III.

ANALYSES OF GREEK STATUARY BRONZES.

	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.	Iron, per cent.	Nickel, per cent.	Sulphur, per cent.	Analyst.
Statue in the Art Museum, Dorpat.	88.54	11.46	....	....	....	....	....	Gobel.
Statuette	88.51	10.13	....	....	1.02	0.34	Trace	Bibra.
Statuette	80.91	10.13	5.25	0.31	....	0.12	Trace	Bibra.
Statuette	89.96	9.22	....	....	0.44	0.38	....	Bibra.
Fragment of drapery, fifth century B. C.....	84.49	9.47	5.31	....	Trace	....	....	Wingham.
Statue of Dionysius, Graeco-Roman period	85.05	10.35	4.65	....	Trace	....	....	Wingham.
Statue from Ephesus, fourth century B. C...	89.04	6.09	4.87	....	....	....	....	Natterer.
Vase, 336 to 324 B. C...	81.76	10.90	5.25	....	0.15	Cobalt 1.22	....	Flight.
Bowl from Roman settlement in Nubia.....	80.81	13.08	5.14	....	0.29	Ni&Co 0.46	....	Gowland.

Cakes of Roman Copper

Among the varied remains which are representative of the Roman occupation of Britain, few are of greater interest to the metallurgist than the cakes of copper found in North Wales and Anglesea. A typical example of one of these cakes is illustrated in Fig. 5. Its weight is 26 pounds, 12 ounces, and it is now in the British Museum. Another cake found near the old mines at Llandudno, is stamped with the words *socio roma*, meaning *to my partner at Rome*. The form and character of these cakes afford unmistakable evidence of their history. They had been obtained by smelting sulphide ores, and the copper, according to Pliny, who in this case appears to be fairly trustworthy, was at first brittle and useless, and in order to obtain malleable metal therefrom, it was mixed with lead and melted several times. This operation was evidently conducted with a free access of air, and the lead, by its oxidation, aided in the removal of the impurities from the copper. That the process was a fairly successful one is shown by the analyses in Table IV, although from the skill shown by the Romans in other metallurgical work better results might have been expected. The earliest Roman alloys are those of the fifth century B. C. Their chief peculiarity is their large content of lead, namely from about 19 to 25 per cent, the tin being about 7 per cent. They are worthless from a practical point of view, but formed the alloy of which the large coin of the republic was cast. This coin was known as the "As," and weighed from 8 to 11 ounces. The analysis as given by Phillips was as follows: Copper, 69.69 per cent; tin, 7.16 per cent; lead, 21.82 per cent; iron, 0.47 per cent; cobalt, 0.57 per cent; nickel and sulphur, a trace.

Table IV.

ANALYSES OF ROMAN COPPER COINS.

	Copper, per cent.	Tin, per cent.	Lead, per cent.	Iron, per cent.	Nickel, per cent.	Arsenic, per cent.	Antimony, per cent.
Copper coins, Caligula, 37 to 41 A. D...	99.24	0.10	0.46	0.20	Trace	....	....
Copper coins, Vespasian, 60 to 79 A. D...	99.53	....	....	0.27	0.20	0.20	....
Copper coins, Vespasian, 60 to 79 A. D..	99.13	0.22	Trace	Trace	0.33	....	0.32

The copper-tin-lead bronzes also appear to have been used by the Romans for engineering and industrial purposes. An interesting example is afforded by the broken shaft of a water wheel, which was found in the lower Roman workings of the north lode of the Rio Tinto mine. This wheel dates from the first century, about 70 to 81 A. D., and the analysis, as given by Thompson, follows: Copper, 77.3 per cent; tin, 9.2 per cent; lead, 10.5 per cent; iron, 1.1 per cent; arsenic, 0.5 per cent; silver, 10.2 ounces per ton, and gold, 0.2 ounce per ton. The Roman statuary bronze also contained lead in proportions from 6 to 12 per cent. This was probably due to the influence of Greek practice, the lead being added to the bronze to increase its fusibility and fluidity.

Influence of Lead

The presence of 5 per cent of lead in bronze, it might be concluded, would greatly diminish its tenacity, and to determine if this is true, the

Table V.

ANALYSES OF ROMAN STATUARY BRONZE.

	Copper, per cent.	Tin, per cent.	Lead, per cent.	Iron, per cent.	Zinc, per cent.	Nickel, per cent.	Artimony, per cent.	Analyst.
Colossal statue	78.33	10.77	10.24	0.14	....	0.52	....	Fellenberg.
Statuette	78.77	9.03	12.07	0.13	....	Trace	....	Bibra.
Statuette	87.36	6.23	6.20	Trace	Trace	0.21	....	Bibra.
Apollo, Gallo-Roman, first century A. D.	80.70	6.44	9.97	Trace	Trace	....	....	Wingham.

Table VI.

ANALYSES OF ROMAN BRASS.

Coins.	Copper, per cent.	Tin, per cent.	Zinc, per cent.	Lead, per cent.	Iron, per cent.	Antimony, per cent.	Arsenic, per cent.	Nickel, per cent.	Analyst.
Augustus, 30 B. C. to 14 A. D...	87.05	0.72	11.80	Trace	0.43	Trace	Trace	Trace	Bibra.
Tiberius, 41 to 54 A. D.....	72.20	....	27.70	....	....	....	....	....	Gobel.
Nero, 54 to 68 A. D.....	77.44	0.30	21.50	Trace	0.32	0.20	....	0.24	Bibra.
Vespasian, 71 A. D.....	81.97	....	18.68	0.14	0.12	....	....	....	Phillips.
Trajan, 98 to 107 A. D.....	77.59	0.39	20.70	....	0.27	....	....	....	Tookey.
Sabina, wife of Hadrian, 100 to 137 A. D.....	82.35	0.43	16.84	Trace	0.38	Trace	Trace	Trace	Tookey.
Other objects:—									
Fibula found at Mayence ..	75.07	0.20	24.45	....	0.28	....	....	....	Fellenberg
Armlet	82.01	1.79	15.30	0.80	Trace	Trace	....	0.10	Bibra.
Fibula	84.45	1.72	12.31	1.44	0.08	....	....	Trace	Bibra.
Needle, Ireland..	84.27	2.36	14.70	....	....	....	....	....	Church.

writer made tests of the tenacity of an alloy containing copper, 88 per cent; tin, 7 per cent, and lead, 5 per cent. It was found that it was only 1 per cent less tenacious than a copper-tin alloy consisting of nine parts of copper and one part of tin. It may be pointed out, that the addition of lead to bronze was and is largely practiced by the Japanese, not only to increase its fusibility and fluidity, but to impart to the objects cast of the alloy a rich brown patina. In this connection Pliny states that by the addition of lead to Cyprian copper, the purple tint is produced that characterizes the drapery of these statues. Characteristic analyses of Roman statues are given in Table V.

Copper and Zinc Alloys

Zinc as a distinct metal was unknown in early times, in fact as late as the 16th century it was unknown in Europe. It is occasionally found in the early bronzes as an accidental impurity, and was only intentionally added to Roman coins in the time of Augustus, about 20 B. C. to 14 A. D., when brass was made for the first time in the history of the world. One of the earliest examples is a coin, which contains 17.31 per cent zinc. Although the Romans knew nothing about zinc, they had discovered that by melting copper together with a certain ore, a yellow alloy of deeper golden hue than bronze could be obtained. Zinc was first employed for coins, which had a higher value than bronze, even up to the time of Diocletian, 286 to 305 A. D., when six parts of brass were worth 8 parts of copper. In the fifth century it is stated by Procopius that brass possessed a value not much less than that of silver.

The method employed by the Romans in making brass from copper and calamine was a very simple one. The calamine was ground and mixed in suitable proportions with charcoal and copper in granules or small fragments. The mixture was carefully heated in a crucible to a temperature sufficient to reduce the zinc in the ore to the metallic state, but not high enough to melt the copper. The zinc being volatile, its vapor permeated the copper and converted it into brass. The temperature of the furnace increased and the brass was melted and poured into molds. This process was so effective, that until a comparatively recent period all brass was made in Europe by this ancient method. It was called calamine brass, and was generally believed to be superior in mechanical properties to brass made by using metallic zinc. As far as it is possible to ascertain, brass was first made in Europe, by adding metallic zinc to copper, by Emerson in England in the year 1781.

The percentage of zinc in Roman alloys varied from 11 to 28 per cent. For ornamental purposes and armor the Romans had an excellent alloy. Several rosettes and studs were unearthed while excavating in the old Roman city of Silchester, Eng. The thinness and rich golden color of these rosettes were so remarkable that the writer analyzed them with the following results: Copper, 80.42 per cent; zinc, 18.77 per cent; lead, 0.09 per cent; iron, 0.62 per cent, and silver, trace. The brass stud contained copper, 82.31 per cent; zinc, 17.11 per cent; lead, 0.08 per cent, and iron, 0.45 per cent. Both the rosette and stud were made from practically the same alloy and of all the copper-zinc series of alloys, those which contain from 15 to 20 per cent zinc possess the greatest ductility. Therefore, the brass of which these rosettes are made is notably of the composition best adapted for making such ornaments and is that which would be employed at the present time. The Roman alloy is identical in composition with Tournay's alloy, which contains copper, 82.5 per cent, and zinc, 17.5 per cent. On account of its rich color and great ductility, it is used for the manufacture of jewelry made in imitation of gold. Analyses that represent selected examples of Roman brass containing maximum amounts of zinc, are given in Table VI. That the Romans were the inventors of brass, cannot be doubted, as the alloy is not found in Greece or elsewhere, until the time of the Roman Empire.

Ancient Methods of Purifying Copper

In the 11th century great care was bestowed on the purification of the copper intended for use in the manufacture of calamine brass for objects of art, as it was known that brass contaminated with lead could not be gilded satisfactorily. The process was conducted on a small scale and is de-

Table VII.

ANALYSES OF MEDIEVIAL BRASSES.

	Copper, per cent.	Tin, per cent.	Zinc, per cent.	Lead, per cent.	Iron, per cent.	Nickel, per cent.	Antimony, per cent.	Analyst.
Statue at Munich, 1600 A. D.	76.90	0.64	19.69	2.68	0.17	0.10	....	Hampe.
Bas-relief, Germany, beginning of 17th century....	65.34	5.04	25.64	2.09	1.79	0.10	....	Bibra.
Memorial brass, England, 14th century	66.64	Trace	23.27	....	0.08	....	....	.....
Memorial brass, England, 1456 A. D.	67.54	1.16	24.16	7.14	....	....	....	Gowland.
Memorial brass, England, 1470 A. D.	66.81	2.56	28.50	2.13	....	....	....	Gowland.
Memorial brass, England, 1504 A. D.	64.00	3.00	29.50	3.50	....	....	....	.....
Angel's head, 17th century, Germany.	59.35	1.30	37.63	Trace	1.13	0.39	0.20	Bibra.

scribed as follows: "An iron dish of suitable size is lined inside and out, with thoroughly mixed and beaten clay, which is thoroughly dried. The lined dish is then placed in a forge fire in such a position that the wind from the bellows may strike partly within and partly above the vessel. The copper is then charged and the fuel is heaped on top the metal and the fire is urged until the metal is melted. The bath is skimmed and fine ashes are sprinkled on the surface. The copper is then stirred with a dry piece of wood, and the operation of covering with ashes and skimming and stirring is repeated several times, until it is judged that the metal is sufficiently purified, when it is poured into molds and tested by hammering while still red hot. If it breaks or splits, the melting process is repeated."

The composition of calamine brass as made in Europe up to the middle of the 17th century is interesting, but does not throw much light on the causes of the superiority attributed to this method of making the metal, as compared with that made by the direct union of copper and zinc.

In Table VII analyses of a number of medievial brasses are given. With the disappearance of calamine brass, one of the last links in the chain connecting the modern metallurgy of copper and its alloys with antiquity is broken. An important link, however, still remains in the *cire perdue* process of casting bronze, a practice in which it hardly can be said that the modern founder is any further advanced than the Greek founders of some centuries before the present era.

European Converter Practice

Castings similar to American blackheart malleables in both quality and composition are cast from converter metal in several European foundries. As a short blow only is required, the slag and wear of the converter are reduced to a minimum. This process, therefore, gives cheaper metal than can be produced by direct melting in the cupola or air furnace. The application of the small converter to the production of malleable castings opens up a wide field. In addition, the small converter also may be employed for making cast iron of high tensile strength. The process consists of mixing white iron that has been blown in the converter and raised to a high temperature with molten pig. The metal, as a result of the chemical reaction, is raised to a temperature that is unattainable in the cupola, and this greatly improves the physical properties of the metal. The characteristic composition of this iron is as follows: Carbon, from 2 to 3 per cent; silicon, from 1 to 2 per cent, and manganese, less than 0.5 per cent. When producing large quantities of this metal, the charge may consist of cheap pig and gray scrap, since the limit of 0.1 per cent of phosphorus, requisite in the case of steel castings, need not be adhered to.

There is still a wide field open for development by the small converter. This consists of a combination of the converter and the electric furnace. Steel produced by the acid Bessemer process is not always of the proper chemical composition, since the phosphorus and sulphur cannot be eliminated, and the percentage of these constituents is determined by the raw material used. By the use of a one-ton converter in conjunction with a one-ton electric furnace, each alternate charge can be refined in the electric furnace for high quality castings, the other charges being used for ordinary steel castings. A ton of mild converter metal can be refined in the electric induction furnace in less than two hours, and the phosphorus and sulphur contents can be eliminated almost entirely. The cost of refining a ton of steel in the electric furnace is about $5. With a small residual charge, the electric furnace can be left under current for several hours without injury, so that continuous operation is not indispensable. When molten steel from the converter is not available, the electric furnace can be charged with solid material, though in this case about 900 kilowatts will be consumed for each ton of steel produced. Using molten metal only 300 kilowatts are required.

Molding Bronze Injectors

AN INTERESTING method of molding a bronze injector was described by G. Hughes in a paper presented before the Intsitute of Metals at the fall meeting of this organization held at Newcastle-on-Tyne, Eng. To successfully mold a locomotive injector both the flask and pattern must be in four parts. The upper view, Fig. 1, shows a longitudinal section of the mold which illustrates the various parts into which the pattern is divided and which are indicated by the letters, *A*, *B*, *C* and *D*. The divisions of the flask are clearly shown by the lines indicating the joints. The flasks are made of iron and the bars are cast in both the cope and drag. The cope bars, *F*, are placed vertically, while the bars in the drag are placed flat across the flask as shown at *E*, and serve to hold the sand, as neither bottom boards nor plates are used. The bottom of the drag is struck-off flush with the sides of the flask and when it is rolled over, it is set upon a bed of sand on the bench. When the mold is completed it is lifted off its bed, and any sand that may adhere is struck-off by sliding the bottom across the edge of the bench. The bench edges, in British brass foundries, are usually made of an iron plate. The mold is then carried to the floor and is set on another levelled bed of sand, ready for casting.

When beginning to mold the injector, the part of the pattern *A*, Fig. 1, is placed on a follow-board with the joint for the cope part down. The first cheek half of the flask is placed over the pattern with the cope joint next to the board. This part of the flask is fitted with horizontal fixed gaggers to support the sand. These gaggers are shown in the two cross-sections of the mold, Fig. 2. The pattern is then rammed and the joint is made around the seating for the lower part of the pattern, as illustrated in Fig. 1.

Preparation is made at one end of this cheek for a pouring gate, which is located as shown by the dotted lines in Fig. 1. The second part of the cheek is then fitted. This cheek part of the mold is also provided with projecting gaggers similar to the other cheek. These gaggers are arranged to support the thin portion of sand between the body of the injector and the flange. Before placing this part of the flask in position, the portions of the pattern immediately under the projecting gaggers are covered with molding sand, as it would be difficult to tuck it under after the flask is in position.

The flange *C*, Fig. 1, is then attached and the sand is packed well underneath it. The flask is then filled with sand and rammed, provision being made for a joint around the flange. This joint is required to permit the withdrawal of the flange. The drag is next placed in position, rammed and rolled over, the follow-board is removed and the cope joint is made. The drag is then ready to receive the cope part of the pattern. At this stage, provision must be made to carry the green sand drawback, *G*, Fig. 1, between the two super-imposed

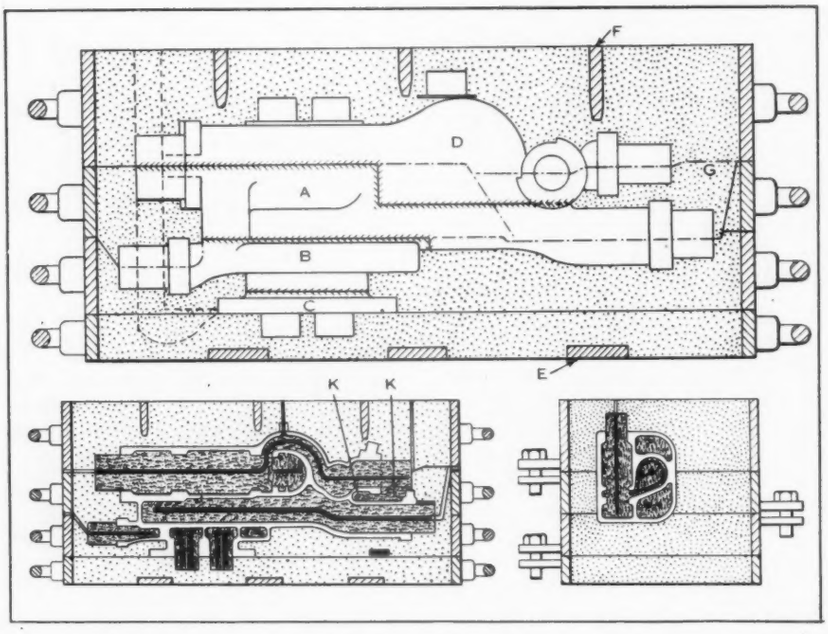

FIG. 1—LONGITUDINAL AND CROSS-SECTION OF A MOLD FOR A BRONZE INJECTOR

delivery pipes. This drawback is carried by the lifting plate, *H*, Fig. 2. This is shown also by the dotted lines in the horizontal mold section, Fig. 2. The lifting plate is clay-washed and is laid over the leg end of the pattern. A layer of sand is placed on the plate, and three gaggers are placed on each side to carry the overhanging part of the joint. The cope part of the pattern is then bedded to make an impression over the plate. The cope is then removed and two nails, *K K*, Fig. 1, are placed across this part of the mold to carry the portion of sand between the overflow and delivery pipes. The pattern is then replaced and the joint is built-up to the center of the curved section of the outlet in the cope part of the pattern. The parting is made and the cope part of the flask is placed in position with a gating plug over the gate in the cheek. The pocket of sand, *M*, shown in the longitudinal section, Fig. 2, is secured by gaggers, and the cope is rammed, lifted off and the various parts of the pattern are drawn in the reverse order to which they were put into the mold. The casting is gated at two points, on the bottom flange and at the joint at the cope parting of the cheek. After the mold is finished and cleaned, it is dusted with powdered plumbago, skin-dried and made ready to receive the cores.

The Cores

In making the cores, red sand, manure, and coal dust only are used. For the large core, *N*, in the upper cross-section of Fig. 2, owing to the complicated bends into which it is shaped, one core iron is bent and fitted to the box and is then used as a pattern and cast in brass. By this means a correctly shaped core iron is obtained for each succeeding core, so that no time is wasted in bending core irons for each injector. For the small cores a special iron is bent each time a core is required. In making the cores, one half of the core box is filled with sand, and before it is rammed a clay-washed core iron is laid in the soft bed of sand. Additional sand is then filled-in, rammed and parted to the level of the box. The other half of the core box is also rammed and cleaned off to the joint. Each half is then clay-washed, vented, the two halves are fitted together and the core is finished. Some of the cores do not require wax vents, as string vents can be used instead. After the cores are dried they are thickly coated with blacking and then are dried again. The core boxes should be made of strong and well seasoned lumber, so that they will withstand rough treatment. The prints on the core boxes should be dead lengths to the prints on the pattern, so that the molder will have no fitting to do when placing the cores in the mold.

The manner in which the cores are assembled in the mold is shown in the longitudinal section through the mold and cores in the lower part of Fig. 1. The cores are complicated and one of the cores which pierces the flange requires anchoring on both sides, at the point where it passes underneath the over-hanging portion of the ejector steam passage. The highest part of the core in the cope must be held down with a chaplet. The number of cores should be reduced to a minimum to avoid joints. These are difficult to reach and if they are not effectively closed, they will permit the metal to enter, producing fins which will obstruct the free flow of water in the passages of the injector.

The metal used for these castings follows: Copper, 84 per cent; tin, 8½ per cent; zinc, 5 per cent, and lead, 2½ per cent. This alloy has been found to run clean castings free from oxidation and scum in the intricate passages of the injector.

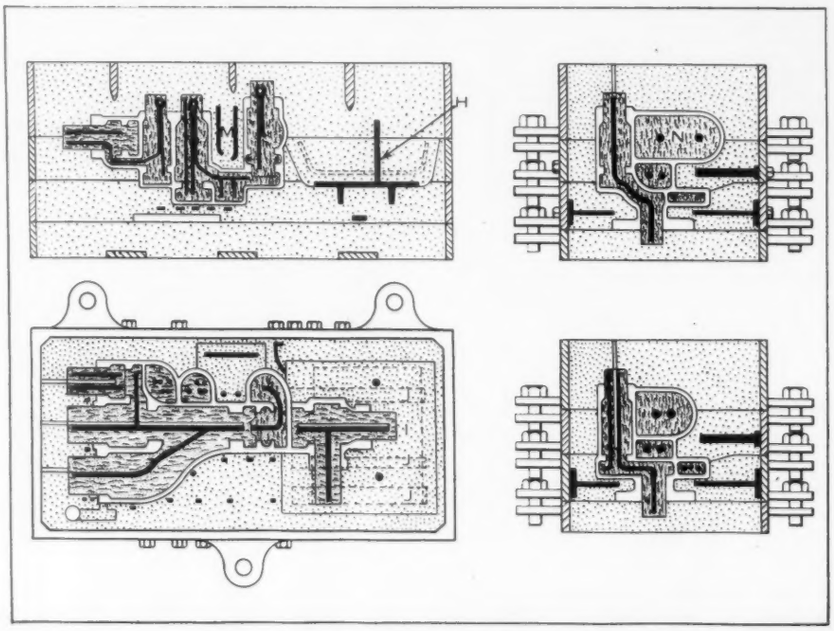

FIG. 2—LONGITUDINAL, HORIZONTAL AND CROSS-SECTIONS OF AN INJECTOR MOLD, SHOWING THE LOCATIONS OF THE CORES

A Large Iron and Brass Foundry in Switzerland

A Brief Description of the Casting Departments of the Plant Operated by Sulzer Bros. at Winterthur

AT WINTERTHUR, Switzerland, the firm of Sulzer Bros. operates an extensive manufacturing plant which includes large foundries and machine shops and the average number of employes totals 5,500. The plant was established early in the nineteenth century and is the outgrowth of a small brass foundry. In 1834 an iron foundry was added and in recent years the growth of these works has been almost phenomenal. The foundry department is supervised by Albert Sulzer, one of the partners, and the casting shops are among the most modern in Europe. Additions to the foundry department have recently been completed and the design and equipment of these extensions were largely influenced by the American experience of a representative of the company who toured the United States in 1910. Well-equipped chemical and physical laboratories are maintained for making analyses and tests of raw materials and castings, and considerable research work is carried on, not only as applied to gray iron, but the softer metals as well. The bulk of the coke and pig iron used in these foundries is imported from Great Britain and the iron and steel turnings from the machine shops are briquetted for melting in the cupolas.

For the production of castings, three iron and one brass foundry are operated. These departments are all located in separate buildings and the gray iron shops are devoted to the manufacture of light and heavy castings and radiators, respectively. The foundry for light castings was built in 1874. This shop covers an area of 67,800 square feet and is divided into four bays which are served by 16 overhead, electric traveling cranes varying in capacities from one ton to 15 tons. Molding machines are used extensively and an industrial railway track reaches every section of the shop to facilitate the transportation of raw material, and for the shipment of castings to the machine shops. A view of the five cupolas in this shop, which are equipped with fore-hearths, is shown in Fig. 1. This method of tapping the metal from the cupolas is exceedingly interesting and is unlike the practice pursued in casting shops throughout the United States. The spout from the fore-hearth is hinged and when tapping the metal it is swung in position in front of the fore-hearth and overhangs the ladle which is carried on a buggy operating on a track in front of the cupolas.

The core department is located in an annex to the foundry and the sand mixing machines have also been installed in this building. The sand mixers, grinders, as well as the magnetic separators, are located on the second floor of this annex. The casting cleaning department is contained in an annex to the foundry which adjoins the hand-molding section of the light work shop. A vacuum system has been installed for exhausting the dust from the cleaning room.

The heavy work foundry, including core and cleaning departments, covers an area of 77,500 square feet. It is served by 18 overhead electric traveling cranes, varying in capacities from five to 25 tons; two 2-ton hand travelers, one electric 2-ton jib crane and two 2-ton chain hoists. The melting equipment consists of five cupolas equipped with fore-hearths which have capacities of from 8 to 10 tons each. The sand and loam mixing machines are located at one side of this plant. This arrangement facilitates the delivery of the sand and loam to the various floors. For large work, six casting pits have been provided, of varying depths and up to

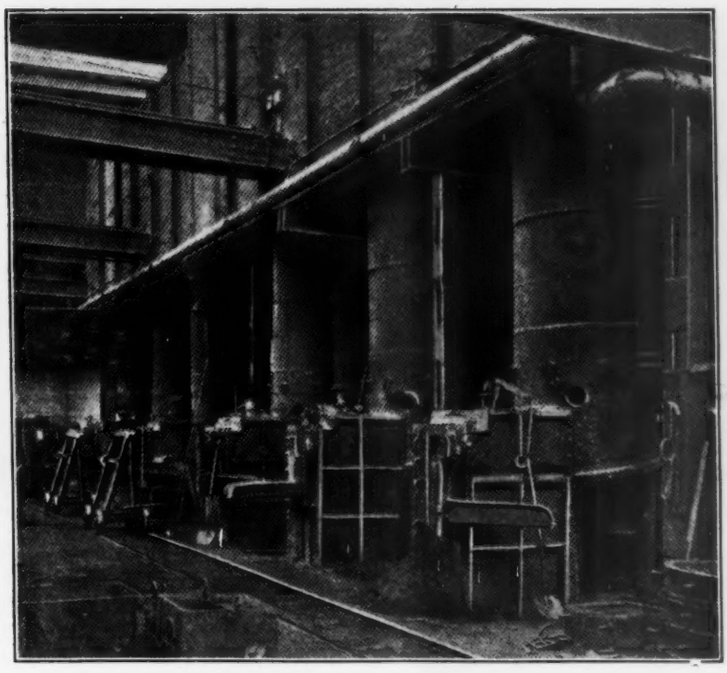

FIG. 1—CUPOLAS EQUIPPED WITH FORE-HEARTHS

FIG. 2—TURBINE WATER WHEEL CAST IN ONE PIECE

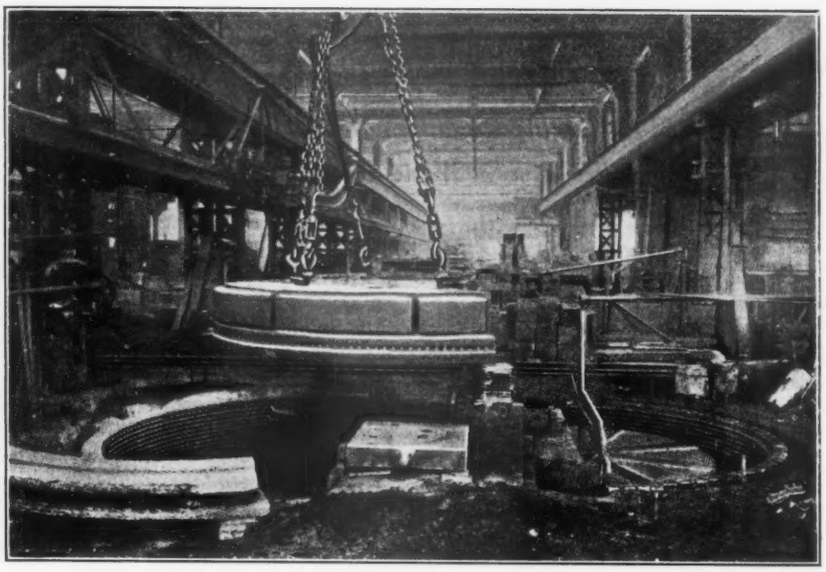

FIG. 3—THE HEAVY WORK FOUNDRY, SHOWING A MOLD FOR A LARGE SHEAVE

19 feet in diameter. The cores are dried in 14 core ovens distributed throughout the shop. In Fig. 3 is shown a view in the heavy work foundry and in the foreground is a mold for a large rope sheave. It will be noted that a section of the core is being lowered into position. Gray iron castings up to 40 tons in weight are made in this shop. Some of these sections are very complicated in design. This is indicated by the turbine water wheel, illustrated in Fig. 2, which was cast in one piece.

One sand and dust-collecting system serves all the cleaning shops. Cement-lined conduits extend underneath the floors of these departments and are connected by chutes with the cleaning floors, benches and emery wheel stands. The openings of these chutes are covered with gratings through which the sand and dust fall into the conduits. The dust is withdrawn by a fan to a dust collector and the sand is removed by a hydraulic elevator.

In addition to its numerous other lines, Sulzer Bros. manufacture heating plants and have equipped a foundry for the exclusive manufacture of radiators. This shop is commanded by 16 cranes, varying in capacities from ½ to four tons. A view of the radiator foundry is shown in Fig. 5 and in the foreground is illustrated a mold for a hot water boiler section. A view of the light work foundry is illustrated in Fig. 4.

This company operates one of the largest brass foundries in Europe, the shop being located in a two-story building covering nearly 10,000 square feet. The office, store rooms and sand-mixing plant are located on the

FIG. 4—A GENERAL VIEW OF THE FOUNDRY FOR LIGHT WORK

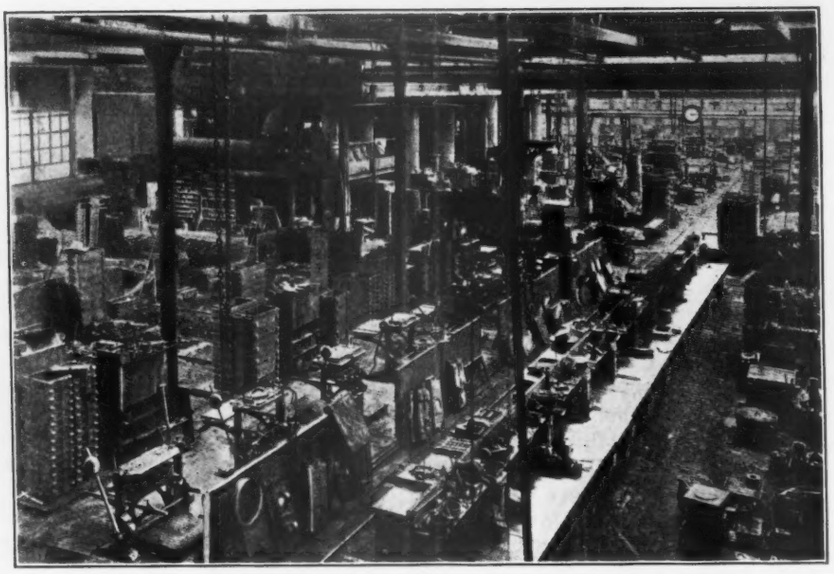

FIG. 5—A VIEW OF THE RADIATOR SHOP

first floor and the furnaces are on the second floor. The melting equipment consists of four Piatt-Bauman crucible furnaces, as well as two smaller furnaces, as shown in Fig. 6. In this view the telescopic hoods over the Piatt-Bauman furnaces are shown in the background. Two of these furnaces have a capacity of 450 pounds per heat and the other two, 650 pounds per heat. The mold drying stoves and one of the trucks for carrying the molds are shown in Fig. 7, while in Fig. 8 is another view of the brass foundry, showing the heavy work floor.

The H. W. Johns-Manville Co., New York City, announces the removal of its Louisville office from the Lincoln Savings Bank building to the Paul Jones building. The office is in charge of J. R. Chowning.

Increasing the Output

By P. Dwyer.

During a somewhat eventful and varied career, I have yet failed to find a foundryman who conducted his business for the benefit of his health, or as a means of whiling away a few idle hours. There may be a few, for the curiosities and idiosyncrasies of the foundry are many and their name is legion, but I have not met them. On the contrary, all those who conferred the honor of their acquaintance on me, or allowed me the privilege of working in their shops, seemed to be in the business for the sole purpose and sordid of gathering in the illusive dollar. I have often thought over these things while en route from one city to another and felt comforted with the thought that there were times when the foundryman would willingly exchange his bed of down, where he tosses all night with one mental eye on the probable profits and the other on the certain and necessary expenses connected with the business, for my comfortable corner in a box car with nothing on my mind and less in my pocket.

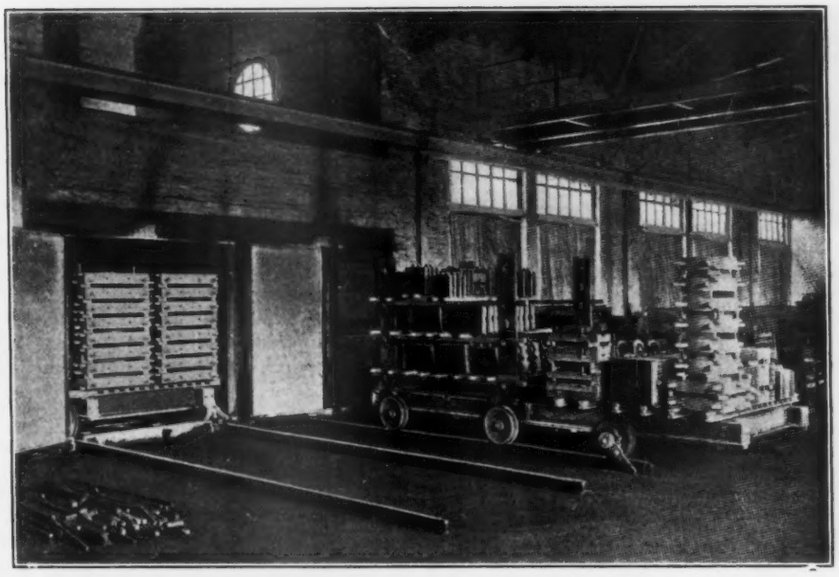

FIG. 7—MOLD DRYING STOVES IN THE BRASS FOUNDRY

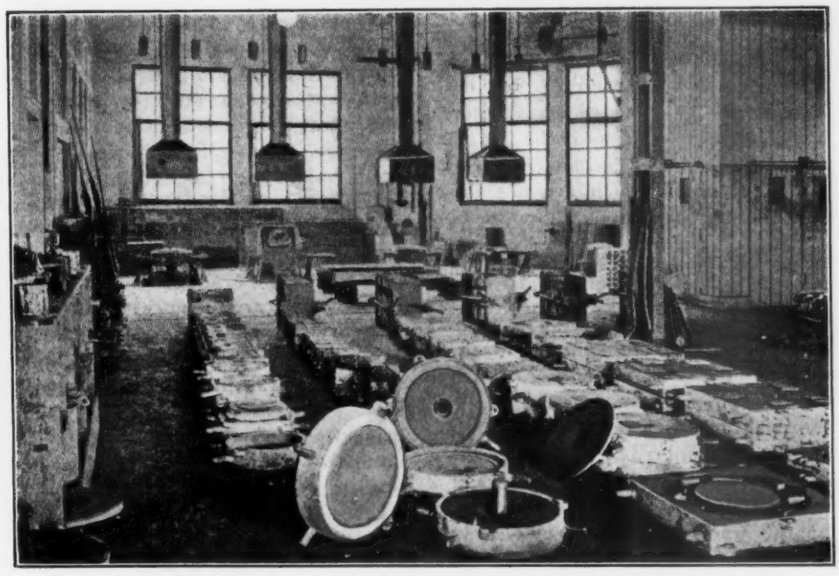

FIG. 6—BRASS FOUNDRY, SHOWING MELTING FURNACES IN THE BACKGROUND

There are many systems in operation with a view of increasing the output or decreasing expenses or both, and perhaps a description of the method used in conducting the shop with which the writer is at present connected, may prove of interest. The building is 200 x 100 feet and is divided in the usual manner into a center and two side bays. The main bay is commanded by two electric traveling cranes of 40,000 and 50,000 pounds capacity, respectively. There is a large door at either end, through which a standard gage track projects about 20 feet, that at one end opening into the flask yard, which is served by a boom derrick, operated by a donkey engine. Through this door all the large flasks are carried in and out and all the castings shipped in the rough are loaded direct on flat cars. The other door opens into a cleaning room and pattern storage and through another door the truck runs direct into the machine shop. One of the side bays is devoted to all the light work, floor and bench, with the exception of a space about 20 feet long and the entire width at one end for the use of the foundry carpenters and about the same area taken up at the other end by the foundry office and a small store room, known as the cage, in which all, or nearly all, the shop tools and rigging are kept when not in use.

This cage is also occupied by a fero-

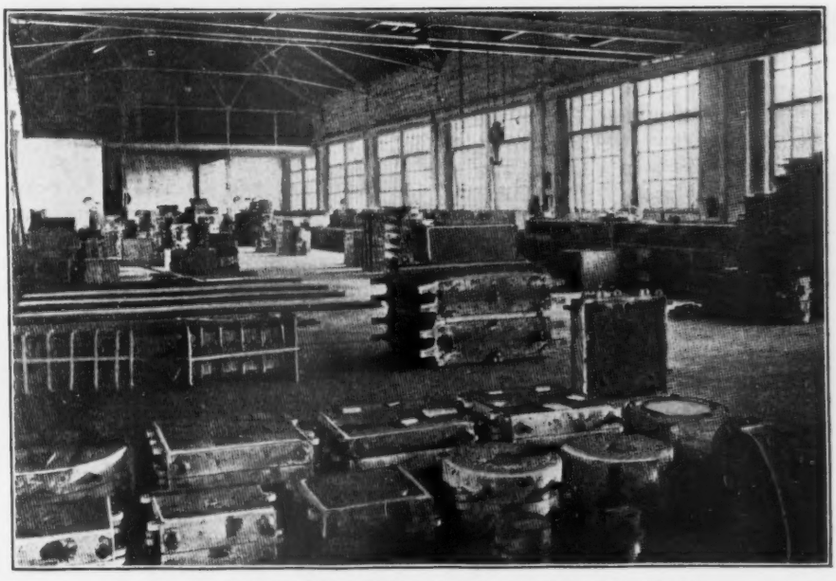

FIG. 8—HEAVY WORK FLOOR IN THE BRASS FOUNDRY

cious individual who must have come from Missouri. He takes a scout around the shop several times during the day and politely wishes you to show him why certain articles were not returned. This saves considerable time, for molders have an absent-minded way of leaving shop articles, such as turnbuckles, lifting hooks and screws, sledge hammers, clamps, iron flask pins and other small articles lie in the sand by their feet, where they are in danger of getting lost or buried. When a man needs any of these things, instead of sending his helper on a tour of the shop, bothering some men and indulging in pleasant conversation with others, generally on subjects altogether foreign to his mission, he goes directly to the cage, and if the object is not there, the bird in the cage can direct him to the man who has it.

The Foundry Bake Shop

The other side bay, divided into three sections, the lower with the atmosphere charged with the aroma of glue and molasses and sometimes with a whiff which one gets on passing a bake shop, is occupied by the core-makers. Here are two externally-fired ovens of standard type, each 25 feet long, 13 feet wide and 9 feet high, with two tracks in each and four cars. One is used by the coremaker and the other is used for drying loam and dry sand work. In addition, there are two small shelf ovens, bottom-fired with soft coal. These coremakers appear to have something of the salamander in their make-up, judging by the ease and facility with which they flit in and out of a red hot core oven and hand you a core which one would feel like carrying away with a pair of tongs. There is one thing certain, they will not have much trouble getting acclimatized if they go where the rest of the shop crew cheerfully consign them after the heat is poured off and the shop is filled with the smoke, fumes and gas from their creations.

The Ostrich-Like Cupola

The middle section is taken up by the cupolas, of which there are two, one 48 and the other of 60 inches inside diameter. The smaller is used for heats up to 40,000 pounds, while the larger, like an ostrich, will refuse nothing that comes along. The blast for the smaller is furnished by a fan, belted to a 20-horsepower electric motor and the larger is served by a rotary blower, driven by a 25-horsepower motor and as both empty into the same main pipe, the two blowers are used in conjunction when the big furnace gets busy. The small furnace is good for about 12,000 pounds an hour and the large one for 20,000 pounds. One corner of the shop has been given over to the brass molders and is equipped with a small oven, 12 x 10 x 8 feet, for drying some of the work. A battery of three, pot furnaces and a small air furnace fired with bituminous coal, constitute the melting equipment. The air furnace can deliver 600 pounds of metal that would run needles an hour after charging and never turn a hair.

Polite Conversation and the New System

It used to be the custom here, as it is in many shops of the writer's knowledge, for all molding operations to be suspended when the blast went on, and it was a source of constant anguish to the superintendent to come in the foundry any time between 3 and 6 p. m. and with the exception of a few men pouring a ladle, to find nothing doing. This led to many altercations between him and the foreman and even to the exchange of some small courtesies which are not to be found in the hand-book of polite conversation. The result was the posting of a notice one day to the effect that on and hereafter the molders would mold 10 hours each day. The helpers were drilled, trained and organized to carry sufficient metal during the first part of the heat, to pour off the side floor. In this way the side floors could be all poured-off and shaken-out inside of an hour, leaving each man 2 or 2½ hours each to continue molding. On the crane floor the men who were casting that day would either start another job, give some man a hand out who was behind, or work with some man who was not going to cast that day. There was some natural opposition at first on the men's part, for whoever heard of a molder being satisfied? They have, however, gradually adapted themselves to the change and everything is quiet and peaceful, if a foundry can ever be said to be peaceful, and the output has been increased from 10 to 15 per cent. As this foundry is run in connection with an iron and steel-making plant, where breakdown jobs and jobs which "must be cast today sure," are the rule and not the exception, this means quite an item.

The H. W. Johns-Manville Co., New York City, has acquired the exclusive selling rights for the I. P. Frink reflectors and illuminating specialties.

The Use of Iron and Steel Briquettes

By M. A. Escher

Some very interesting articles on the utilization of cast iron borings have appeared from time to time in the columns of THE FOUNDRY, to which might be added a few details regarding the briquetting process now being used in Europe. These briquettes are made by hydraulic pressure, and in my own practice I have found it feasible to use as high as 60 per cent of briquettes in the charge, together with 40 per cent of soft scrap, and in the baby Bessemer I have used up to 90 per cent of steel briquettes in the charge. Steel briquettes permit of the addition of carbonizing material during their manufacture in any quantity desired, which makes them highly useful for the production of semi-steel, as they can be mixed half and half with steel scrap, or can be used entirely without steel scrap.

In a converter steel casting plant, the scrap produced, which amounts to from 30 to 35 per cent of the melt, has to be remelted, and a good way is to add about 50 per cent of carbonized steel briquettes, and the balance high silicon pig iron. Silicon can also be added to the borings before they are compressed and the cost of the resulting steel will be no greater than the cost of open-hearth steel. Generally speaking, it may be said that cast iron borings, when briquetted, produce an iron of the nature of charcoal iron, or the same quality that is obtained in the air furnace. In using briquettes for ordinary light work, care must be exercised to add the proper amount of silicon and phosphorus to the mixture. Sulphur will not be absorbed when melting briquettes in the cupola as the borings are mixed with lime water which protects the metal from sulphur and at the same time serves as a binder. Loose borings or briquettes made without any additions are liable to take up sulphur from the fuel.

The offices and plant of the Brown Specialty Machinery Co., Chicago, manufacturer of core machines and core-making equipment, are now located at 2440 West Twenty-second street. The factory occupies double the floor space of the former plant and the offices are combined with those of the Brown Bros. Mfg. Co., in the Brown Bros. building. Elmer A. Rich Jr., general manager of the Brown Specialty Machinery Co., has been elected president and general manager of the Brown Bros. Mfg. Co.

THE BRASS FOUNDRY

A New Alloy of High Tensile Strength

By C Vickers

A NEW high tensile copper alloy, recently developed in France, is made by melting chromium and aluminum together at a high temperature for one hour, the proportions of each metal being 11 pounds. When the aluminum and chromium have been thoroughly incorporated, 242 pounds of copper are added, and the entire charge is held in a molten condition in the furnace for a period of one-half hour, after which 55 pounds of nickel are added and another hour-period of soaking follows. The metal is held in the furnace a total of 2½ hours, which is contrary to the practice of melting alloys of copper. After the nickel has been added and at the end of the period of rest, 44 pounds of zinc are alloyed with the mixture, which is then poured into ingots. The proportions of copper and chromium can be varied in accordance with the use for which the alloy is intended, but no change is permissible in the quantity of aluminum, or the order in which the metals are to be added.

To the experienced metallurgist it would seem that any change that could be made in the order in which the metals are added would be in the nature of an improvement. For instance, nickel being a highly refractory metal, could be charged with the chromium and aluminum, and in fact this method actually has been followed in producing a chrome-nickel bronze of similar proportions. The resulting alloy fulfilled all requirements as to quality, rivaling high-grade steel in strength and resistance to impact. It may be asked why the aluminum, not being a refractory metal, should be added together with the chromium and nickel, and a direct answer cannot be given because, to the writer's knowledge, the experiment of adding the aluminum at a later stage has never been tried. It is assumed that the aluminum aids in the fusion of the chromium by dissolving it in the same manner in which copper will dissolve nickel, or zinc will dissolve iron or copper, and at a temperature much lower than the melting point of the more refractory metal. It is fair to presume, however, that the aluminum is injured by much prolonged melting at a very high temperature, and that it would be better to form the alloy in some way that would avoid the necessity of holding the more fusible parts of the mixture in the furnace at a high temperature. Several methods might be suggested. In this country chrome-nickel bronze is being manufactured by the Naulty Smelting & Refining Co., Philadelphia, the product being known as chromax bronze.

Chromax Bronze

The composition of this alloy is similar to the French metal, and to all intents and purposes it is the same. The proportions of the metals in the mixture are said to be as follows: Copper, 66.66 per cent; zinc, 12.13 per cent; nickel, 15.15 per cent; chromium, 3.03 per cent, and aluminum, 3.03 per cent. The tensile strength of the alloy is 79,000 pounds per square inch and there is reason to believe that this figure is not too high. The elongation is 3.3 per cent. Continuing the criticism of the French method of making chrome-nickel bronze, it would be interesting to know in just what form the chromium is used. It might be added as ferro-chromium containing from 60 to 70 per cent of chromium; fused chromium metal containing from 98 to 99 per cent chromium; chromium chloride, or as chrome-copper containing 10 per cent of chromium. If the latter metal is used the aluminum could be added at any stage, and it would not be necessary to keep the metal soaking in the furnace any longer than necessary to incorporate the nickel. Chromium is almost an infusible metal and is very difficult to alloy with copper by direct melting, as the copper will not dissolve the chromium in the same manner as nickel.

Ferro-chromium melts at a temperature lower than chromium metal and is employed as an addition to steel, but attempts to form an alloy of ferro-chromium and copper, by melting the latter under charcoal and after superheating it to a high temperature, adding the ferro-chromium in the powdered form, were unsuccessful. Chrome-nickel bronze, therefore, cannot be made by direct fusion of the chrome and copper in ordinary furnaces, but the alloy can be made by melting the chrome, nickel and aluminum together, afterwards adding the copper in small pieces, until a fusible alloy is formed that will not chill in the furnace. The remaining copper part of the charge can be added in the usual manner and the zinc is added last. This is a good method of making this alloy, as the more refractory metals are melted first, with the exception of the aluminum, which is considered necessary to aid in the fusion of the chromium.

If it is believed advisable to melt the chromium and aluminum together and if this can be accomplished successfully, the best manner in which to complete the alloy would be to add a portion only of the copper charge. About 50 pounds could be added, and when dissolved, the nickel should follow. The copper-aluminum-chromium mixture, being heated to a high temperature, would dissolve the nickel if the latter were added gradually, after which the addition, at suitable intervals, of the balance of the copper, would keep the temperature of the molten mass sufficiently low to permit the zinc to be finally added without undue oxidation. In the French method, all of the copper is charged before the nickel, and to

dissolve the latter, the bath must be raised to a temperature too high for the economical addition of the zinc.

Another method by which this alloy could be formed consists of using the aluminum as a fuel to melt the chromium in the same way in which it will melt any other metal, in the form of thermit. This consists of granulated aluminum mixed with the oxide of the metal it is desired to reduce. This would prove an excellent method of making the alloy, as the chromium-thermit could be placed in the furnace and after the reaction the aluminum could be added if thought desirable, or the copper could be added in sufficient quantity to bring the fusibility of the mixture well within the capacity of the furnace. The nickel could be added next, followed by the balance of the copper in the manner previously suggested.

If the use of the 10 per cent chrome-copper is preferred for making the alloy, it will be necessary to melt 110 pounds of chrome-copper, to which is added in the following order 55 pounds of nickel, 143 pounds of copper, 44 pounds of zinc and 11 pounds of aluminum. After the chromium has been melted and alloyed with a portion of the mixture, there is no need of allowing the metal to soak in the furnace any longer than may be necessary to keep the temperature sufficiently high to dissolve the rest of the metals in the alloy. Otherwise, it will be difficult to obtain castings free from oxides which greatly reduce the strength of the alloy.

For this reason it is advisable to melt the metal twice, the first heat of new metal being poured into ingots, which are afterwards remelted to make the castings. The metal should be hot and liquid when poured and the castings will then be practically free from oxidation. The color of the alloy is white and it takes a fine, silvery polish. The fracture is fine and dense, especially after being remelted. One test bar made from the first melt of new metal had a tensile strength of 66,670 pounds per square inch, although after being broken it was found that the bar was unsound to the extent of one-third of its area. Chrome-nickel bronze, owing to its high melting point, has a denser structure and greater compressive strength than manganese bronze. It can be rolled into sheets and wire, and while somewhat more difficult to cast than manganese bronze, there is reason to believe that chrome-nickel bronze will replace the latter for many purposes, particularly where a high tensile, non-ferrous alloy is required

Effect of High Temperatures of Copper Alloys*

By G D Bengough

THE determination of the changes effected by increases of temperature on metals and alloys, is of considerable interest both from a practical and scientific standpoint, as in practice non-ferrous alloys are often required to withstand the effects of both heat and stress. A knowledge of the behavior of alloys when subjected to high temperatures is also of value in rolling mill and forging operations, as it indicates the proper temperatures at which the work should be accomplished.

Some of the earlier researches along this line were made at the Portsmouth (Eng.) dockyard in 1877, and showed that a large fall in tenacity occurred at temperatures between 350 and 400 degrees Fahr. In 1890 a comprehensive investigation was made and published by Martens on the mechanical properties of iron, steel and copper at high temperatures. The test bars in this investigation were heated in a bath of paraffine for temperatures up to 366 degrees Fahr. and in a bath of lead or tin alloy for temperatures up to 752 degrees Fahr. Further investigations of this subject were conducted in 1899 by Unwin, and in 1900 by Le Chatelier, and in 1907 Rosenhain published the results of some high temperature tests on copper-aluminum alloys, which were supplemented by other tests in 1910 by Rosenhain and Lantsberry. The results obtained by Le Chatelier for rolled copper show a remarkable similarity to those obtained during the present investigation.

As the methods of heating the test bars in baths of oil or lead adopted by the earlier investigators was not sufficiently accurate, a vertical resistance furnace, wound with strip platinum, was used for making these tests. Care was exercised to insure the uniform heating of the bars to prevent oxidation and consequent scaling.

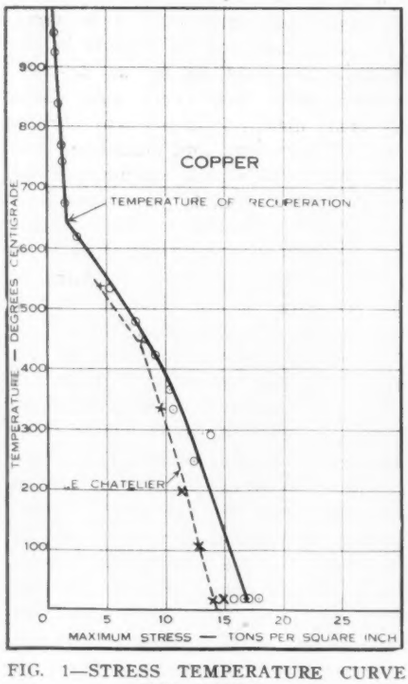

FIG. 1—STRESS TEMPERATURE CURVE FOR COPPER

The tests made on rolled copper showed at ordinary temperatures a tensile strength of 16.5 tons with an elongation of 32 per cent. At 486 degrees Fahr., the tensile strength fell to 12.7 tons and the elongation to 28 per cent. while at 552 degrees Fahr., the tensile strength had increased to 13.7 tons and the elongation reached the lowest point in the series of experiments, namely 9.3 per cent. Further increases of temperature resulted in a rapid decline in the tensile strength of the copper, while the elongation was increased from 27 to 29.6 per cent. The greatest elongation was found at a temperature of 740 degrees Cent., equivalent to 1,364 degrees Fahr., at which point the enormous elongation of 78 per cent was reached. The tensile strength, however, was only 1.2 tons. The stress temperature curve for copper is shown in Fig. 1, and it will be noted that at 650 degrees Cent., 1,202 degrees Fahr., the curve is almost a straight line to the melting point, 1,065 degrees Cent. From 650 degrees to ordinary temperatures, the curve is convex.

In the case of rolled aluminum, the stress temperature curve was similar in form to that obtained with copper The temperature of recuperation is 395 degrees Cent., 743 degrees Fahr

*Abstract of paper presented before the Institute of Metals.

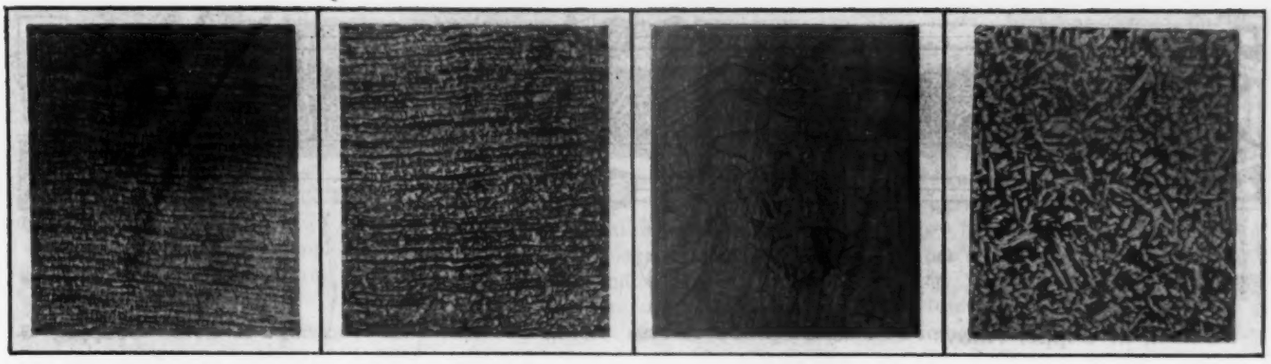

FIG. 2—CUPRO-NICKEL ANNEALED ONE HOUR AT 700° C.

FIG. 3—CUPRO-NICKEL ANNEALED ONE HOUR AT 800° C.

FIG. 4—CUPRO-NICKEL ANNEALED ONE HOUR AT 900° C.

FIG. 5—MICROSTRUCTURE OF EXTRUDED METAL

These micro-photographs show a magnification of 80 diameters.

The points particularly noted in the curve for copper and aluminum were that a well-defined change in the direction of the stress temperature curves occurred at 650 degrees and at 395 degrees Cent., respectively.

Copper-Nickel Alloy

The stress temperature curve obtained in the case of a copper-nickel alloy also greatly resembled that of copper. The temperature of recuperation was higher, namely 710 degrees Cent., 1,310 degrees Fahr. The elongation declined until a temperature of 650 degrees Cent. was reached, and then increased rapidly, reaching its maximum at 700 degrees Cent. From this point to 750 degrees Cent. there was a falling off in elongation, but from 750 degrees it increased until a temperature of at least 1,010 degrees Cent. was reached. The melting point of this alloy was 1,190 degrees Cent., and the composition follows: Copper, 79.99 per cent; nickel, 19.60 per cent. and iron, 0.41 per cent. It was found that the copper-nickel bars scaled considerably when heated to high temperatures, the scaling being much worse than in the case of pure copper. The effect of annealing on the microstructure of the copper-nickel alloy is shown in Figs. 2, 3 and 4.

An alloy of cast brass containing copper, 69.88 per cent; nickel, 0.5 per cent; zinc, 27.9 per cent, and lead, 0.64 per cent, lost steadily in tensile strength as the temperature increased and the elongation fell off rapidly until a temperature of 400 degrees Cent. was reached. Beyond this point, in common with all similar alloys, recovery set in and was rapid after 450 degrees Cent. Tests also were made on two alloys of Muntz metal, the composition of which were as follows:

(*A*) Copper, 60.52 per cent; zinc, 38.80 per cent, and lead, 0.40 per cent.

(*B*) Copper, 59.52 per cent; nickel, 0.39 per cent; zinc, 39.43 per cent, and lead, 0.74 per cent.

The elongation of alloy *A* fell off rapidly up to 300 degrees Cent., and reached a minimum value at about 350 degrees. From this point it increased rapidly up to a temperature of 395 degrees Cent. Alloy *B* gave variable results in the range of temperature between 400 and 500 degrees Cent., and a comparison of the curves of the two alloys showed that they act quite differently at all temperatures below 700 degrees Cent. The difference is so great that it might be concluded that they are entirely different alloys. The sensitiveness of these alloys to very small differences of composition is of great industrial interest and importance. The microstructures of both these alloys of Muntz metal are shown in Figs. 6 and 7.

Other Alloys Tested

Other alloys tested were a cast brass, Fig. 9, composed of copper, 56.75 per cent; zinc, 43.20 per cent; and lead, 0.10 per cent, and a complex brass consisting of copper, 55.1 per cent, aluminum, 0.07 per cent; nickel, 0.28 per cent; zinc, 41.89 per cent; tin, 0.77 per cent; lead, 0.52 per cent; iron, 0.84 per cent and manganese, 0.36 per cent. The latter alloy was extruded, and its microstructure is shown in Fig. 5.

The results of these investigations show that all alloys lose strength rapidly when heated; that the elongation falls until a certain point is reached, which point varies with the alloy, after which recovery sets in and the elongation becomes greater with the decrease in tensile strength until the melting point is approached.

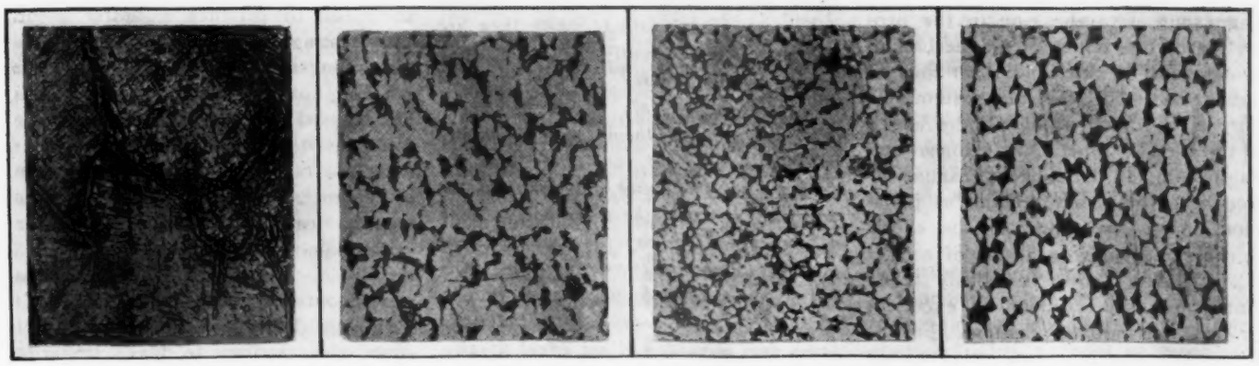

FIG. 6—MUNTZ METAL, *A*.

FIG. 7—MUNTZ METAL, *B*.

FIG. 8—MUNTZ METAL, *B*, BROKEN AT 625° C.

FIG. 9—CAST BRASS

These micro-photographs show a magnification of 80 diameters.

Brass Foundry Difficulties

Solved by Experts

Silicon in Copper Alloys

It has been stated frequently that silicon is a desirable addition to hydraulic bronze mixtures, and that these castings withstand high steam or water pressures without leakage. An alloy that has been recommended for this purpose follows: Copper, 78 pounds; tin, 12 pounds; zinc, 1¼ pounds; brass, 10 pounds, and silicon-copper, 0.12 pound. The brass, we understand, is the usual copper-zinc alloy, but the amount of silicon is so low, only about 0.01 per cent, that we have wondered what possible effect it could have upon the metal. We also have been advised that lead should be used in small amounts in alloys subjected to water or steam pressure, and that not more than 2 per cent should be added.

If silicon-copper is used in composition or gun metals, it must be added in very small quantities; otherwise it will do more harm than good. The percentage of silicon-copper in your alloy is as much as should be used in any mixture. If there is any lead in the alloy, silicon should be carefully excluded from any brass or bronze. The addition of silicon will not improve your alloy, and we do not advise its use. Magnesium should be substituted and the percentage of this deoxidizer must be very low, or it also will do more harm than good. Two ounces of magnesium to 100 pounds of metal would be entirely too much for any alloy of copper. It would be desirable first to alloy the magnesium with the zinc in the proportion of one ounce of magnesium to two pounds of zinc, and from four to eight ounces of the magnesium-zinc alloy is as much as should be added to the metal. Silicon, manganese and magnesium, as deoxidizers, cannot be used with the same freedom as phosphorus. A knowledge of the effects of these elements on alloys of copper will indicate how cautiously they should be used. Silicon is excellent for making copper castings, but is not so effective in alloys. Magnesium causes brittleness in brass and bronze, unless it is used in extremely small amounts. Manganese produces *cold shuts* in the castings and spoils their appearance. It also causes oxide discolorations which show in the fracture of the metal. All these elements must be properly used, otherwise it is better not to use them at all. If you desire to make an alloy as hard as the one given and for the same purpose, it would be better to first melt the copper, then deoxidize with boron suboxide, which would leave the copper practically in the tough-pitch condition; the tin and zinc then are added, the brass and silicon-copper being omitted. This would make a much better alloy than the one you mention. The claim that lead is injurious in alloys subjected to pressure is merely a theory and is not borne out by practice. Highly leaded alloys have been used for castings subjected to water pressure, from time immemorial, and are still used. The much-exploited gun metal—copper, 88 per cent; tin, 10 per cent, and zinc, 2 per cent—is a very difficult metal to cast so that it will withstand high pressures of water, and has been replaced frequently by leaded alloys with good results.

Mixtures for Babbitts

We would like a babbitt formula that will compare favorably with some of the high-priced babbitt mixtures on the market. We also would like to be informed whether it is a good plan to leave brass castings in the molds over night, and whether it is safe to shake out heavy brass castings while they are still red hot? Recently we made some heavy engine brasses that cracked on the inside when left in the molds to cool. We made them again, shaking out while red hot, and they did not crack. Did this have anything to do with it, or was there probably some difference in the way the castings were poured? Sometimes, when we are in a hurry for a casting, we cool it in water after it has been out of the sand for a few minutes. What effect, if any, does this have on brass castings?

A high-grade babbitt that is comparatively hard can be made from the following mixture: Copper, 5 pounds; antimony, 10 pounds, and tin, 85 pounds. Melt the copper under charcoal in a crucible furnace, gradually adding the antimony, and when dissolved, remove the pot from the fire and add the tin. The heat absorbed by the crucible, and the molten copper and antimony, will melt the tin, and when the latter has been dissolved, the mixture should be stirred thoroughly and cast into ingots. If a babbitt kettle is available, the tin can be melted therein, and the molten copper and antimony is poured into the tin. Use pulverized soft coal as a flux. A cheaper alloy, suitable for lining heavy brasses, is made as follows: Copper, 3¾ pounds; lead, 25 pounds; antimony, 11¼ pounds, and tin, 60 pounds. Brass castings can be left in the molds all night, if considered advisable, but it is better to shake them out of the sand while hot, as they can be cleaned to better advantage. This is particularly true of heavy castings, as the fins and rough spots can be removed easily while they are hot with a spade or heavy file. It is not safe to shake-out heavy castings while too hot as they are very weak when at a high temperature, and they may be broken or may bleed. Cooling in water is supposed to soften brass castings, but this is questioned, as it does not seem to make any difference in their physical qualities. The principal reason for the practice of cooling in water while hot is to clean them, or to produce a better color. The castings, however, should be below redness when this is done. The cracking of the engine brasses was not caused by leaving them in the sand, as the mold would not offer sufficient resistance to the contraction of the metal to cause a rupture. The trouble was due to shrinkage, the castings having been poured with cold metal. The second time the castings were poured with hotter metal and shrinkage did not occur. It does not affect the castings to leave them in the sand until cool, or to remove them while hot, provided they neither bleed nor crumble when handled.

A Stiff, White Alloy

We would like to obtain the formula for a stiff white alloy. We are of the opinion that the metal employed in making flat latch keys would be satisfactory for our purpose. Can you give us any idea of the composition of this alloy?

The metal used for making flat keys must be very stiff, and is generally an alloy of copper, zinc and nickel, being in fact a German silver. Several different formulas are used for this purpose, a typical mixture following: Copper, 65 per cent; nickel, 12.50 per cent; lead, 1 per cent; tin, 0.25 per cent; iron, 0.50 per cent, and zinc, 20.75 per cent. The copper and nickel should be charged together in the crucible with a liberal supply of charcoal, and when melted the iron can be added in the form of tin plate, or by the addition of yellow prussiate of potash used as a flux. When tin plate is used, the small percentage of tin in the mixture may be omitted safely. After the tin plate is dissolved, the metal should be stirred thoroughly, and the rest of the mixture added. The nickel should be grain nickel.

Sand Mixtures for Cores for Brass

What proportion of flour is usually added to sharp sand for making stock cores? How is resin sand mixed for brass castings? What proportion of molding sand is it necessary to mix with sharp sand for making flour cores that will stand up in the oven while drying? Can you suggest a good mixture for making cores for splicer ears for electric railway overhead work, and also a mixture for general cores for brass work? We would like to obtain some practical formulas for cores that have been actually used which will insure mixtures that will successfully resist the pressure of the metal.

The proportion of flour added to sharp sand for making stock or other cores for brass castings, is one part of flour to ten parts of sand. If the cores are round and are set on end in the oven, mix as follows: Seven parts of lake sand; three parts of molding sand, either old or new, and one part of flour. Resin for a core sand mixture should be pulverized and should be screened through a fine sieve, until reduced to a powder It can be purchased in this form. This mixture should consist of sharp sand, floor sweepings and burnt sand, in such proportions that when damp, it will be sufficiently strong to permit of handling the cores without breakage when removing them from the core box. The proportion of resin to sand may vary from 1 to 14, to 1 to 30, according to the desired hardness of the cores and the manner in which the sand is mixed. For splicer ear cores, use one part of linseed oil to 32 parts of lake or silica sand, or mix one-half gallon of boiling water, one quart of linseed oil and 35 parts of sand. The following will be found satisfactory for cores for ordinary brass castings: Riddle one part of burnt sand or floor sweepings, one part of molding sand and one part of lake sand through a No. 16 sieve to remove all lumps. Wet with two gallons of water, to which one pint of glucose and one pound of flour have been added. The flour is added to the water in the form of a batter, after which the glucose is stirred-in. The sand is moistened with this liquid and then is mixed thoroughly. The cores will not require blacking, as they will produce smooth castings without such treatment.

White Alloy for Plumbers' Goods

Can you give us a formula for a white metal that would be suitable for making plumbers' goods? The alloy must be cheap, but we cannot use any soft metal such as the tin and lead series of alloys. What alloy can you suggest that would be as hard as brass and with the same characteristics, but white in color?

The only alloys that will meet the requirements demanded are those containing nickel, and because of the comparatively high cost of this metal, these alloys cannot be considered cheap, as they are more expensive than yellow brass. To obtain a white alloy it will be necessary to use as much as 15 per cent of nickel, as 10 per cent of nickel in this alloy will produce a yellowish white shade. There is no metal, except manganese, that can be used in the place of nickel to whiten copper, and it would not be economical to use manganese, as it cannot be employed in conjunction with iron. Castings made from a mixture containing manganese and iron cannot be machined owing to the fact that the iron exists in the form of nodules in the alloy which destroy the tools. Therefore, manganese-copper made by alloying copper with ferro-manganese cannot be used, and in order to make a white alloy by the use of 30 per cent iron-free manganese-copper, it would be necessary to use an amount of the latter equal to 50 per cent of the entire copper charge in the mixture. The metal, however, would be more expensive than a cheap nickel mixture. The manganese and copper alloy, however, may be given here, as it is an excellent alloy for many purposes, and can be worked with great ease. The following mixture may be used, which is a genuine manganese bronze: Copper, 35 pounds; 30 per cent iron-free manganese-copper, 45 pounds; zinc, 12 pounds, and lead, 8 pounds. To cast the alloy in sand molds it will be necessary to add aluminum to the mixture in the proportion of 2 ounces to each 100 pounds of metal. The following alloy, which is a low-grade German silver, is less expensive than the manganese and copper alloy given above: Copper, 50 per cent; nickel, 15 per cent; zinc, 35 per cent, and aluminum, 2 ounces.

Dipping Brass

Will you kindly advise us of a mixture for a yellow dip metal that will machine easily?

The following alloys are pale yellow in color, and as they contain considerable lead, can be machined easily: Copper, 16 pounds; zinc, 9 pounds, and lead, 1 pound. Or, copper, 16 pounds; zinc, 10 pounds, and lead, 1 pound. If a mixture of a more reddish tint is desired, the following alloy will be found satisfactory: Copper, 67 pounds; zinc, 30 pounds, and lead, 3 pounds.

Annealing Brass Castings

In a paper presented before the Institute of Metals, London, Eng., on the "Influence of Tin and Lead on the Micro-Structure of Brass", F. Johnson laid stress upon the advisability of thoroughly annealing castings made of alloys of copper and zinc that contain tin, before subjecting them to any mechanical treatment, in order to soften the brittle tin compound. These alloys, which are generally known as naval brass, range in composition from copper, 70 per cent; zinc, 29 per cent, and tin, 1 per cent, to copper, 63 per cent; zinc, 37 per cent, and tin, 1 per cent. After being annealed the alloys should be cooled slowly.

Matthew Addy & Co., Cincinnati, in a four-page circular direct attention to manganese by-products for foundry use. This material contains from 10 to 12 per cent manganese, 0.45 to 0.55 per cent silicon, 0.025 to 0.035 per cent sulphur and 0.08 to 0.09 per cent phosphorus.

The Operation of Small Open-Hearth Furnaces

Various Types of Fuel-Oil Burners Are Described With the Arrangement of the Burner Port—How a Small Furnace Was Rebuilt

By B H Reddy

IN THE country where the writer as a boy rambled over the hills and through the woods, there lived in a cabin an old man. There was nothing remarkable about the fact that he lived to be nearly 100 years old; that at 90 he could read newspapers by the hour without the aid of spectacles; that he never had a headache nor had been confined to his bed with illness a day in his life. This, in spite of the fact that he used tobacco continuously from the time he was a boy and used whiskey in moderation during the same time. His possessions seemed to consist mainly of a small piece of property and numerous descendants. When anything was to be done by the family, and if he had an opportunity, he would remark, "Wal, now, doan go too fast. Let's kacalate first." His main occupation seemed to be *kacalatin*, if one were to judge by appearances about his cabin. It is all very well, and at times necessary for one to *kacalate*, but the *kacalashuns* should be used with a liberal application of common sense and judgment gained from experience This especially is applicable to the construction and operation of open-hearth furnaces.

While considerable has been published about open-hearth furnaces of the larger size, from 10 tons upward, little has been written about the smaller furnace, less than 10 tons in capacity. The smaller furnaces are particularly well adapted for steel casting plants. In the larger plants, they are convenient for use when it is not economical to employ the larger furnaces or for making special alloy steel. Only small furnaces, using crude oil for fuel, will be considered in this article, nor will details of construction, bracing, etc., be discussed.

Types of Burners

There are a number of burners of different designs on the market, suitable for use in open-hearth furnaces The feature to be kept prominently in mind, is the thorough atomization of the fuel used. It is not at all difficult to make an efficient burner from pipe and fittings at a very low cost, in an ordinary pipe shop. As previously noted, the fuel must be thoroughly atomized to obtain the best results This can be seen readily by observing the flame in the furnace through a pair of melters' glasses. Whenever there are *stars* in the flame, the oil is not being properly atomized. These stars are caused by small drops or particles of oil projected from the burner. As they burn brightly, they are easily seen as they pass through the flame. They generally fall near the burner, but sometimes are carried a considerable distance when compared to the total length of the flame. Their presence is a positive indication of the waste of oil. A black streak in the flame, beginning at the burner and extending varying distances through the center of the flame, is another indication of the waste of oil. This is quite noticeable to the eye trained to note the characteristics of the different flames.

The tips used on burners are made in a wide variety of forms. In Fig. 1 are shown several shapes in common use which are made from ¾-inch pipe The tip, *A*, seems to aid in atomizing the fuel, but a high pressure on the oil and air must be maintained. Tip. *B*, is similar in shape, except that the slot is wider, in other words, the opening has a greater area. This does not necessitate the use of as high a pressure as the tip previously described. Styles *A* and *B* can be made by a blacksmith by heating and flat-

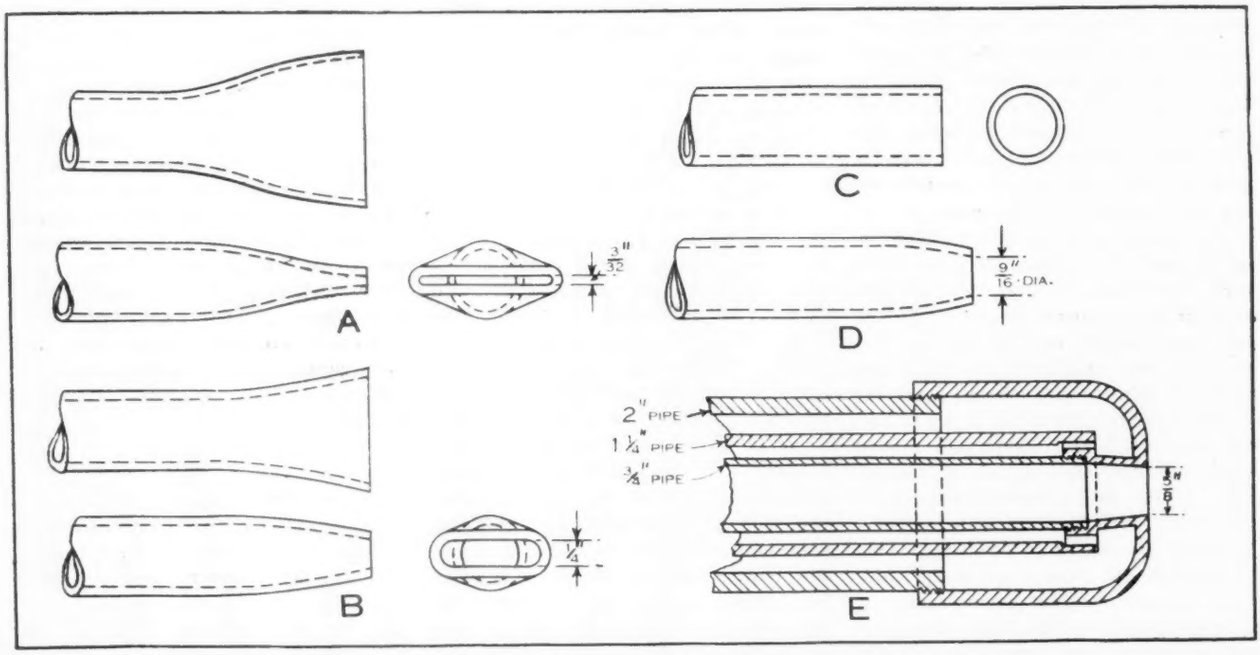

FIG. 1—VARIOUS TYPES OF OPEN-HEARTH FURNACE FUEL OIL BURNERS

tening out the pipe over a flat drift Style *C* is merely a straight piece of pipe, while *D* is a pipe drawn to a reduced diameter at one end. While the size of the opening can be varied, a diameter of 5/8 inch is suggested. In making tips for burners, it is highly important that the end be carefully smoothed on the inside with a file or reamer. If there is any small projection it will cause the oil to drip down from the end of the burner This results in a direct waste of oil. Style *D* seems to be the most desirable form of tip for general use It is easily made and gives a smooth flame which is no longer than that from other styles of tips. It is possible, when using tips *A* and *B*, that the flame will be too wide. When the furnace is narrow, there also is danger of cutting the brickwork at the front and back.

If the burner tip is allowed to project into the furnace beyond the brickwork and becomes hot, there may be trouble from the oil *coking* on the inside of the tip, thereby clogging the opening. This, of course, depends on the quality of the oil used, the smoothness of the inside of the burner and the temperature to which the tip is heated. The tips usually are from 8 to 12 inches long, and are threaded on one end to facilitate their removal and replacement. Frequently the burners are not withdrawn from the furnace at each reversal. Nothing is gained by this, as the tips are burned off or the oil is *coked* inside of the burner, necessitating the replacement of the tip every alternate reversal. To overcome these difficulties, water-cooled tips are sometimes used. At *E*, Fig. 1, is shown a burner which can be made in a repair shop. With a water-cooled burner it is not necessary to withdraw the burner at each reversal, nor is there trouble from the oil coking on the inside. However, it is doubtful if any economies are effected by their use, owing to the increased cost of the burners and the added cost of the cooling water used, especially when the water is purchased. Unless care is exercised in making a water-cooled burner, oil will drip from the tip, especially if it is cooled to a low temperature.

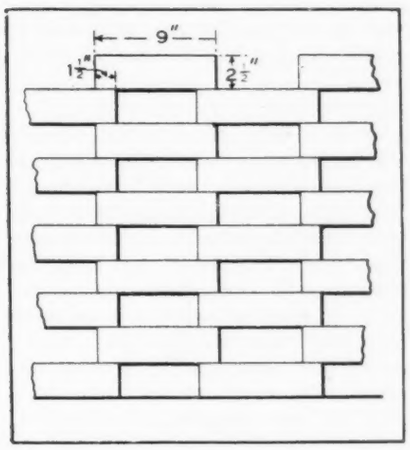

FIG. 2—PLAN OF THE CHECKER WORK

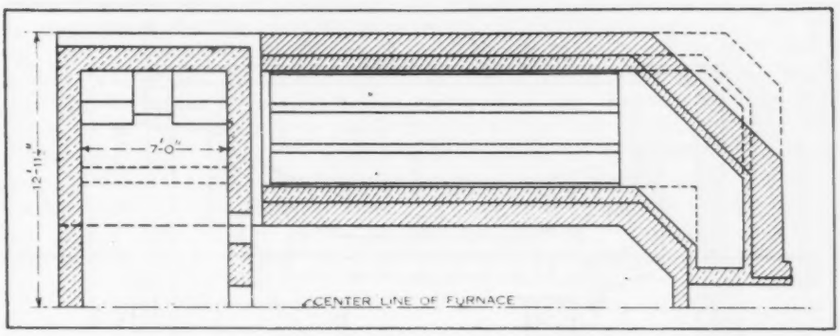

FIG. 3—PARTIAL PLAN OF THE FURNACE AS REBUILT

High and Low Pressures

There are two methods of furnishing oil to the burners. These are commonly known as high pressure and low pressure. Roughly speaking, any pressure under 20 pounds per square inch is called low pressure and over 40 pounds, high pressure. The low pressure is usually secured by means of the gravity system, the required pressure being obtained from a standpipe of sufficient height. Great economy has been claimed for this method over the high pressure system, but there seem to be no convincing reasons why this should be so, aside from the fact that by the gravity system a uniform pressure is obtained, provided the oil is kept at a constant height in the standpipe. This can be accomplished by placing an overflow as required and allowing the excess oil to flow back to the supply tank. The principal objection to the high pressure system is the varying pressure caused by the pulsations of the pumps. This can be overcome in several ways. A simple method is to provide a tank on the delivery line, in which an air cushion is carried. The oil should flow in at the top of the tank, so as not to transmit the pulsations, which will occur to a certain extent, in spite of the air cushion, if the pump delivers directly into the oil at the bottom of the tank. When the pulsations of the pump are transmitted to the oil, it shows clearly in the furnace by the alternate lengthening and shortening of the flame. Herein is the so-called wastefulness of the high-pressure system, as sufficient oil must be supplied to the burner so that the shortest flame will be of the required length. The lengthening of the flame beyond this point constitutes a waste of oil.

Atomizing the Oil

For atomizing the oil, air or steam may be used. If steam is employed, it can be used direct from the boilers, or after superheating, by passing it through suitable heating coils. From a series of experiments conducted by the writer, it is apparent that in ordinary practice nothing is gained by using steam in the burner at a high temperature. It is only necessary to employ a dry atomizing medium. Some have claimed great economies from the use of steam instead of air. In a series of experiments conducted

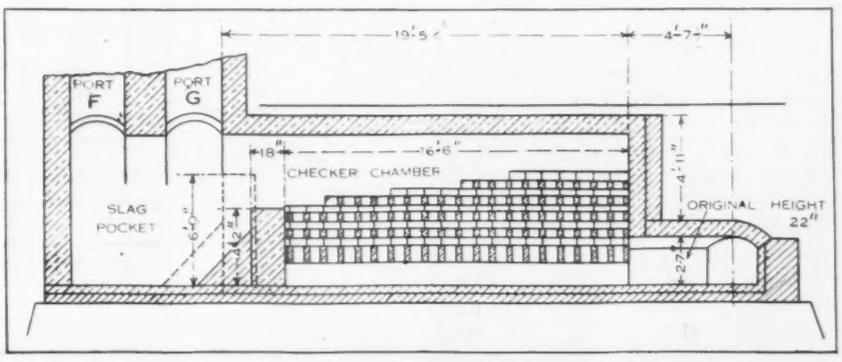

FIG. 4—SECTION THROUGH THE PORT, SLAG POCKET AND CHECKERING CHAMBER

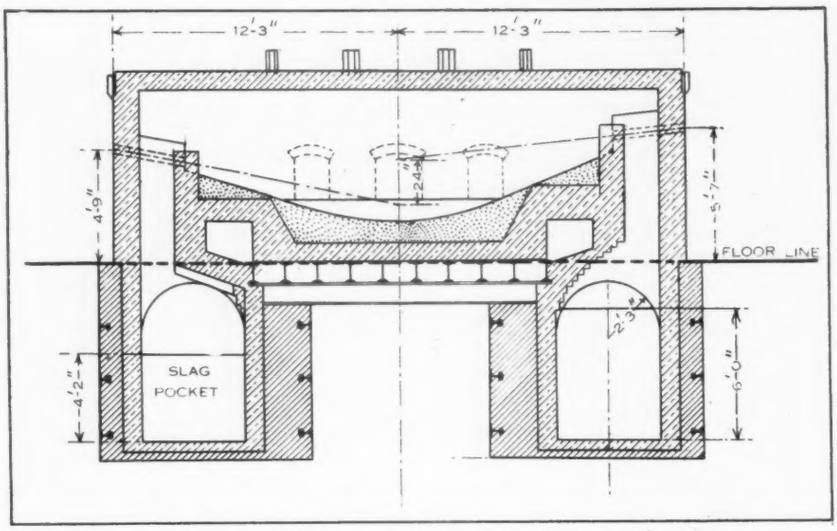

FIG. 5—SECTION THROUGH THE FURNACE AND SLAG POCKET

at one plant it was ascertained that it requires 13¾ pounds of steam per minute to furnish the proper size flame, when used direct in the furnace at a temperature of 54 degrees Fahr. of superheat. Almost the same amount of steam was required to drive an air compressor at the proper speed to furnish sufficient air to the burner to secure a flame of the same size. Taking into consideration the losses from friction, radiation, etc., a smaller amount of air was required per minute than of steam. This was undoubtedly due to the oxygen in the air which aided combustion. Undoubtedly, steam can be used with the basic process, but when the acid process is employed, it is an entirely different proposition. The use of steam results in the use of a greatly increased quantity of sand to keep the furnace bottom in proper condition. This increased cost will more than offset any economies effected by the use of steam.

The Burner Ports

It is usually advisable to allow the brickwork of the port or tunnel through which the burner is inserted into the furnace to project two or three inches beyond the end of the burner. This protects the end or tip. As is well known, the end of the furnace opposite the burner in use is subjected to the greatest amount of heat. When the burner is in use, the cold air drawn through this port and the oil and air passing through the burner, keep the port at a low temperature. The burner at the opposite end of the furnace has no oil nor air passing through it and, in addition, is subjected to the intense heat of the flame from the other burner. The heat, however, is drawn out through the burner port, which acts as a flue. This can be overcome by partially withdrawing the burner and allowing air or steam to pass through it, thereby holding back the flame. This can be easily accomplished by drilling a small hole in the back of the plug in the three-way reversing valve, used for reversing the burners. The size of the hole required can be determined by experiment, but it is not necessary to make it more than ⅛ or 3-16 inch in diameter.

Superheating the Steam

It is not at all difficult to secure superheat in steam, but it is quite a different problem to deliver it to the burners. The pipes leading from the coil to the reversing valve and to the burners should be well protected with a high grade pipe covering suitable for withstanding high temperatures. It is advisable to apply a double thickness of covering to the pipes. At one plant an attempt was made to superheat the steam by passing it through a loop of 2-inch extra strong pipe, laid on top of the checkers at the rear of the chamber where the temperature was about 1,600 degrees Fahr. As there was a coil for each burner, the steam was passing through the coils only when their respective burners were in use. In this service the life of the coils did not exceed 4½ days. As this particular furnace ran quite hot in the stack flue, a slot was cut through the top of the stack flue, between the reversing valve and damper, and a coil, made from 1¼-inch standard pipe, was inserted. This coil heated the steam to 1,105 degrees Fahr. and lasted nearly four months. As the stack flue was of ample area, the coil was placed directly across it. In placing a coil in a furnace in which the stack flue was of small area, the coil was laid on the bottom directly underneath the reversing valve. The coil was supported by bricks which raised it about 4½ inches above the bottom. When using superheated steam, it is advisable to have a small opening in back of the reversing valve, regardless of whether the flame is to be held back in the burner port. The steam passing through the pipes and burner is useful for keeping them hot. If this is not done, the benefit of the superheat will be lost and, in addition, water will probably be carried into the furnace, even if means are provided for draining the pipes.

In furnace work it is advisable to avoid using special shapes, and this can be done, except in a very few cases. Special shapes are expensive,

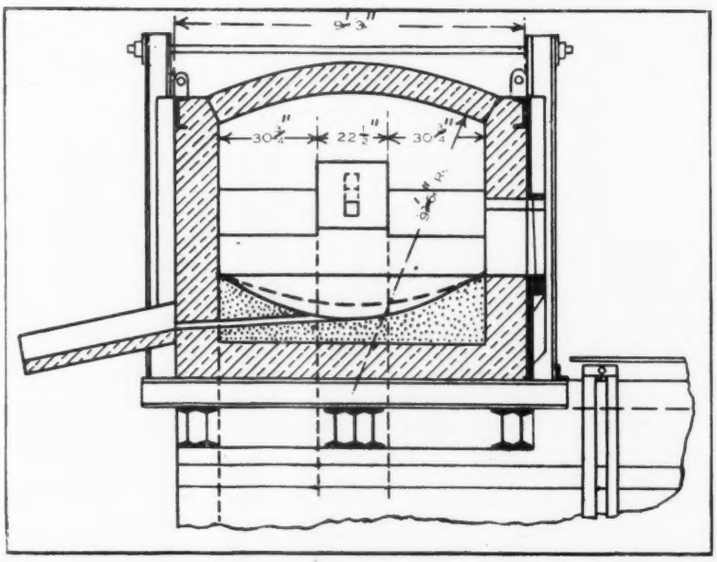

FIG. 6—CROSS-SECTION THROUGH THE FURNACE HEARTH, SHOWING THE INCREASED BOTTOM THICKNESS

are made only to order by the brick-makers, and are liable to be out of stock when needed most for unexpected repairs. The furnace roof should be made of standard size silica brick, 9-inch keys and straights. Sometimes a low roof is advocated for the purpose of holding down the flame close to the bath, but extremes of this type of construction should be avoided. If the roof is too low, combustion is retarded and, in addition, it is soon cut out by the flame. This is particularly true when using oil, as this flame is inclined to be extremely sharp and will cut out brickwork in a very few hours. As the flame is localized to a large extent, it is easy to cut out the brickwork or to cause excessive furnace losses in the metal charged. Occasionally, furnaces are built in which the ports in the ends are not as wide as the body of the furnace. This form of construction is not to be recommended for small furnaces, especially when using oil, as the brickwork is rapidly cut out at the point where the furnace is contracted on the inside.

When starting up a *green* furnace it is customary to dry it out slowly, and to heat it gradually. As the heat is increased, the tie rods across the top of the furnace must be loosened to take care of the expansion of the brickwork and they should be tightened when cooling down the furnace Unless care is exercised, the furnace roof can be ruined easily by improper heating. While silica bricks will withstand high temperatures, they are sensitive to sudden changes and unless care is exercised, the life of the roof will be greatly reduced by the *spawling-off* of the bricks on the inside. The side bracing or brick stays of the furnace should have a heavy steel angle or channel for carrying the weight of the roof as well as for taking the thrust of the arch. The necessity for this is self-evident when the frequent patching and renewing of the front and rear walls is considered

The Hearth

The hearth should be of sufficient length to insure proper combustion. If the hearth is too short and the ports too small, there will be excessive cutting of the brickwork and a tendency for the gases to burn in the ports and down into the slag pockets The bottom should not be too thin, as there will be an excessive loss of heat and resulting cold metal. While the metal may appear hot enough on top, the lower portion of the bath will be much colder and when this metal is used it will result in defective castings and an undue percentage of skulls. It is not clear to the writer why there should be any necessity for long, and correspondingly narrow, chambers and flues for oil-fired furnaces with the added retardation from friction to the passage of the gases. It has been found from experience that it is better to have the checker chambers of greater depth rather than of the same volume, with less height and increased length. As this is true with gas-fired furnaces why is not the same principle applicable to oil-fired furnaces? There are a number of ways in which the checkerwork may be laid, but a very convenient method is shown in Fig. 2 This involves the use of 9-inch straights throughout. As a general rule, not less than 100 square feet of heating surface should be provided for each ton of metal in small furnaces.

Rebuilding a Small Furnace

While in a steel foundry recently, observing the operation of a small open-hearth furnace with one of the officials, the writer ventured to remark that there was something radically wrong with the design of the furnace, not knowing that the designer was present. The latter immediately began a series of violent protestations to the effect that he had carefully *kacalated* all the proportions and he insisted that they were correct. Being unable to fathom the calculations presented, attention was directed to the flame coming out through the burner ports, around the doors and through the cracks in the brickwork. The large percentage of skulls indicated also that something was radically wrong.

Later the writer was afforded an opportunity of making the necessary changes in the design and construction of the furnace. Noting that the metal seemed quite hot in the furnace, but was cold in the ladle, the furnace spout was raised about 8 inches, which compelled the melter to carry a thicker bottom. In the slag pockets no clear, well-defined currents could be seen, but instead the gases moved sluggishly and surged back and forth, indicating that there was some obstruction to their free passage. The furnace was rebuilt as shown in Fig. 3, which is a partial plan view. The original design is indicated by the heavy dotted lines. Fig. 4 is a section through the ports, slag pockets and checker chamber. The bridge wall was reduced in height and was moved toward the checker chamber. The original position of the bridge wall seemed to be such that the gases descending through port, *F*, were deflected upward and retarded the flow of the gases through port *G*. Fig. 5 is a section through the furnace and slag pockets. At the right of the center line is shown the original height of the slag pocket bridge wall, the thickness of the bottom and the position of the burner port. In the section of the furnace at the left, Fig. 5, the center line of the burner port intersects the center line of the furnace at the elevation of the bottom of the doors. As a rule, this insures a good position for the burner port. As shown in the view on the right, the original inclination was not sufficient to obtain the best results, as the burner could not be depressed to the proper angle and was too high at the point where it entered the furnace. The original form of the arches connecting the ports with the slag pockets, as shown at *X*, is indicated at the left, Fig. 5. These arches were changed, as shown at the right, Fig. 5, and no further trouble was experienced. Fig. 6 is a cross-section through the furnace hearth, the increased bottom thickness being shown by the heavy dotted lines.

The ports for the burners should be made so as to permit of the adjustment of the burners by tilting them up or down. This is necessary for the following reasons: When charging and melting down the charge, the burner is tilted upwardly so that the flame will not strike the charge, as the flame impinging upon the cold metal will interfere with proper combustion. It also will cause excessive furnace losses and will scatter and deflect the flame, which is liable to result in the cutting of the walls or roof. It has been claimed that a small open-hearth furnace, properly designed, will furnish melted steel to the ladle with an oil consumption of about 50 tons per gallon or approximately 60 gallons per hour. This may be true. However, one of these *properly proportioned* furnaces used over 100 gallons per hour with an oil consumption in excess of 100 gallons per ton of steel.

Economies Effected

After the furnace, previously referred to, was rebuilt, the oil consumption and the time required for each charge were greatly reduced. Before the furnace was rebuilt it radiated so much heat that the paint was blistered on a cupboard about 20 feet distant. After rebuilding, one could stand close to the furnace with comparative comfort, as the flame was passing through the checkers instead of breaking out through every crack and opening in the brickwork. In

the absence of loam for a wash to coat the outside of the furnace and to close up the small cracks, a wash, made of cement and fire clay, was used. While not as good as the loam wash, it answered the purpose very well. Another advantageous result obtained from the rebuilding of the furnace was in reduction in the melting losses. Before the furnace was rebuilt the skulls averaged 15 per cent of the heats, but after the changes were made the losses were reduced to 30 pounds in six heats. As the heats averaged five tons, the economy thus effected was considerable.

Patterns and the Cost of Production

By J. B. Binns

Beyond the memory of man the pattern shop has been considered a necessary evil — a non-producer. As an apprentice boy my employer used to speak of the pattern shop as the place where he spent all his profits. As a natural consequence, anything was considered good enough for this department, any out of the way corner that could not be used for anything else was graciously designated the pattern shop. The very mention of machinery and the pattern shop at one time would have been considered high treason, and the culprit would have been (very rightly) punished. It is a great national loss that no Charles Dickens ever came

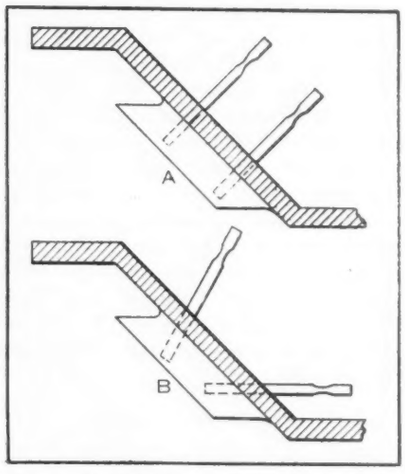

FIG. 1—IMPROPER AND PROPER METHODS OF DOWELING LOOSE PIECES TO PATTERNS.

forth to write the sad tale of those Oliver Twists who dared to ask for machinery.

Picture to yourself the meek patternmaker with his burning gouge and chisel in one hand and a block of wood in the other, on bended knee before the czar of the works—*the boss machinist*—begging for the use of one of his precious lathes. All turning had to be done in the machine shop whenever a lathe could be spared, and all planing and sawing was done by hand. Therefore, is it any wonder, that under these conditions the pattern shop was a thorn in the flesh, a drag on the other departments? Pat-

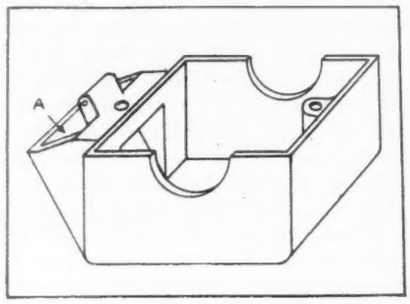

FIG. 2—AN OIL BOX PATTERN

ternmaking as an intermediate step to the accomplishment of an end was too often overlooked even by those who were in closest contact with this work.

Pattern Shop a Money-Saver

With the introduction of machinery in the pattern shop these conditions have been eliminated to some extent, and the wide-awake manufacturer of today realizes that the pattern shop is essentially a money-saver, although a money-spender, and a department to be reckoned with in the production of cheap castings. Patterns are made to make castings, and plenty of them at the lowest cost. "Cheap castings" is the cry nowadays, not cheap patterns. A pattern is first and last foundry equipment and as such should be reckoned with in the castings. Then the pattern shop is placed on a paying basis and the patternmaker is given a little of the credit he is entitled to.

The question of how cheap a pattern can be made should not be the prime consideration, but how cheap can patterns be made so that when sent to the foundry they can be molded as cheaply and quickly as possible and at the same time produce presentable castings. The pattern shop that is conducted to make cheap patterns, irrespective of the foundry, leaving the molder to slick off all corners when paper and leather fillet are so cheap to patch this up and rub that off when it could be done cheaper and much better in the pattern shop, is not fulfilling its duty and becomes a drag.

Province of Patternmaker

The patternmaker is to the molder what the toolmaker is to the machinist—a means to lessen the cost of production; therefore, his position is such that he must go right on piling more and more expense on his own department to save money in the other departments. He must be a first class molder theoretically and must give molding a continual study. If he is anxious to have a first-class reputation as a patternmaker he follows his work through the foundry into the machine shop, and if there is trouble due to his pattern, he finds out why and then does his best to prevent a recurrence of the difficulties.

In patternmaking, as in other things, the details count, and these are too often overlooked as being too trivial to bother with. Yet the details frequently turn out to be vital. When making a gear or wheel in cores, the last core set is the hub covering core; when that is placed, the whole wheel is completed, the mold is closed and is ready for the pouring basin, risers, etc. Yet, only too often this core is made in one piece, which, when being placed over the center core, is liable to carry sand and pieces of core down into the hub. The molder has a kindly feeling for the patternmaker who makes this core in halves, giving him a chance to level and pack his center core and at the same time keep his mold open and clean. The placing of the other half of the core is then a simple operation.

Loose pieces on patterns, like the patternmaker, are a necessary evil sometimes, and if great care is not exercised they become a source of great expense and annoyance to the

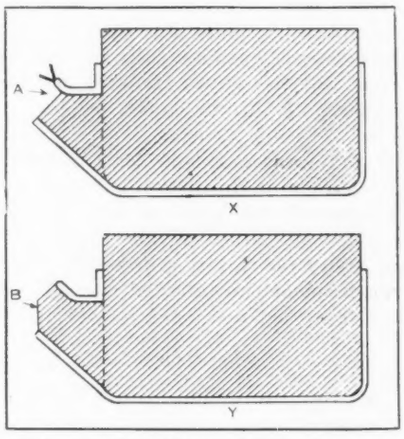

FIG. 3—SECTIONAL VIEWS OF OIL BOX MOLDS

machinist, who, when he comes to lay out the centers, finds that one is out in one direction and the other in another direction. This can be remedied by using two different diameters of dowel pins, thus making it impossible to get pieces reversed. If the holes are bored as at *B*, Fig. 1, instead of as at *A*, which is commonly done, they will form a dovetail that

will hold the piece to the pattern as securely as though attached in position. This also is a boon for the pattern storage, as the piece can be attached to the pattern without the attendant danger of being lost or broken. Wherever possible, loose pieces should be backed by a core so they can be fastened firmly to the pattern.

Oil Box Pattern

Fig. 2 is an oil box with a grease opening at *A*, which is provided with a hinge cover attached to the projecting lug. The patternmaker made the oil box pattern as shown at *X*, Fig. 3, leaving the lug loose to be drawn in after the pattern was drawn. The result was that the lug was frequently too large and out of place, which necessitated additional work in the machine shop. By changing the core to cut through, as shown at *Y*, Fig. 3, and beveling off the print, as shown at *B*, the lugs were made tight and loose pieces were dispensed with entirely. This change in the pattern gave the molder a better opportunity to turn out castings to size.

Fig. 4 shows a combined drum and brake ring, for which an order for a number was recently received. When the pattern was received from storage

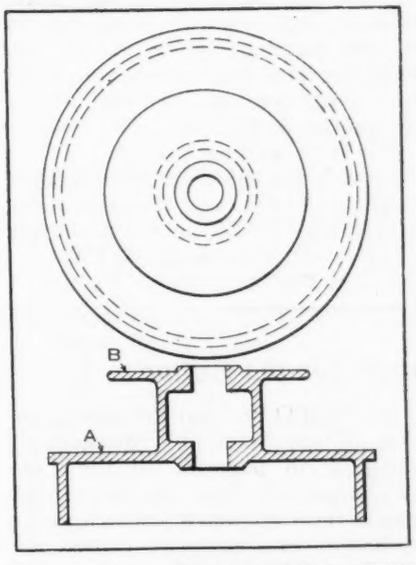

FIG. 4—PLAN AND SECTIONAL VIEW OF A COMBINED DRUM AND BRAKE RING PATTERN

it was found that it was made to be molded as shown at *A*, Fig. 5. It was also discovered that web, *A*, Fig. 4, was broken and could not be repaired. Flange, *B*, was also warped out of shape and the entire pattern was weak as web, *A*, was only ¾ inch thick. The pattern was so constructed that the cost of molding was excessive, entailing the use of a cheek, as illustrated at *A*, Fig. 5. The pattern was changed, as shown at *B*, Fig. 5, and the cheek was eliminated by the core illustrated in this cross-section. This change in the pattern and in the method of molding resulted in the production of three of these castings in two days, as compared with two castings in three days with the former pattern and the three-part mold.

The Chicago Foundrymen's Club

The Chicago Foundrymen's Club has been organized by the members of the Chicago Foundry Foremen's Association and others not members of this organization, but interested in the advancement of the foundry industry. The club has been incorporated and at a recent meeting of the Chicago Foundry Foremen's Association it was decided to disband that society. By the adoption of the term *club* the organization will not be confused with other foundry societies known as associations, and inasmuch as the club is not organized for business purposes, but for establishing more intimate social relations and to promote foundry educational work, the term is considered more appropriate. For the current year the dues are $5 for resident members and $3 for non-resident members. After this year the dues will be $3 for resident and $2 for non-resident members.

Officers of the association have been elected as follows: James Wood, president; H. O. Lange, vice president, and C. E. Hoyt, secretary-treasurer. The directors are A. M. Thompson, E. W. Smith, E. J. Welch, Wm. Pederson, J. G. Garrard, Wm. Breckenridge, Thorfin Mauland and Oliver Goldsmith.

Cracks in Chilled Wheels

By N. W. Shed

Question:—We are experiencing difficulties in casting chilled gray iron wheels, which are about 30 inches in diameter and 200 pounds in weight. The cause of the trouble is the presence of cracks on the chilled tread of the wheel, beginning on the outside edge of the tread and extending across sometimes as far as the flange. At its widest part the crack varies from a hair line to 3-16 inch and extends in depth up to as much as ¾ inch. Occasionally, two or more of a number of wheels cast from one ladle will be found to be cracked when removing the chill, which is done four or five minutes after casting.

Answer: — The cause of cracks in chilled wheels is due to the unequal contraction of the chilled surface. The white iron of the tread of the wheel contracts twice as much as the center and any inequality or irregularity in the depth of chill will have a tendency to produce a crack on the chilled surface. The main body of the wheel should contract uniformly and any variation in tampering the

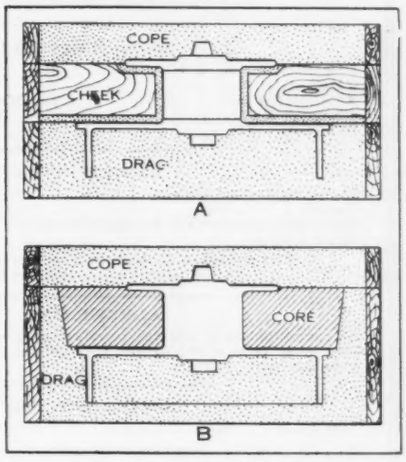

FIG. 5—CROSS-SECTIONS OF MOLDS. SHOWING THE ELIMINATION OF THE THREE-PART BY THE TWO-PART FLASK

sand or in ramming will prevent the uniform contraction on which the whole art of wheel molding depends.

In the May 1911, issue of THE FOUNDRY, Thos. D. West stated that the molten metal in a chilled wheel presses against the unsupported, rapidly solidifying crust of metal, which is in contact with the chill and claimed that it is necessary to have a method of positively centering the crust or shell in relation to the chiller. The metal is in contact with the chill only a few moments before it hardens and then it draws away from the chill. While drawing away the metal begins to check unless the contraction is uniform. Several devices have been proposed whereby the chill continues in contact with the metal as it shrinks. It might be well to change your wheel mixture and a sufficient chill might be secured with a higher silicon. This will undoubtedly reduce the tendency of the wheels to check. Phosphorus should be kept low, not over 0.25 per cent, and the manganese should be about 0.45 per cent.

The H. W. Johns-Manville Co., New York City, announces the removal of its Pittsburgh branch from Liberty avenue, near Ninth street, to Wood street and First avenue. An eight story building will be occupied. This structure is 31 x 96 feet and contains approximately 23,808 square feet of floor space.

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Trade Outlook

DISCUSSING trade conditions, a prominent eastern foundryman, who can speak with authority owing to his extensive manufacturing interests, directed attention to the tremendous increase in the melting capacity which has become operative during the last few years. "While the country has enjoyed its normal rate of growth," he said, "this has not been sufficiently great to absorb the additional melt of the gray and malleable iron, steel and brass foundries. Based on standards of two or three years ago, the tonnage of castings produced today is normal, if not abnormal. Although only a few of the shops are operating at capacity, the present melt would have crowded the foundries to the limit in 1908. Prosperous periods in the casting trade invite new capital. New plants are built and existing shops are extended. Then follows a division of the available business, price-cutting and an era of depression. But the low point has been passed. We are very slowly climbing to the peak which will mark the high point of our next period of prosperity. Buying is still on a conservative basis, but is more widespread and will increase in volume with the opening of the building season and the beginning of other activities, as soon as the weather moderates." Business conditions in the casting industry have been clearly summarized in the foregoing statement. The steel market is characterized by a slight softening in prices. This, however, is not due to insufficient tonnage on mill order books, but is traced to the temporary decline in buying. The pig iron market, in all centers, is quiet, but prices show no inclination to sag. In the south only a few iron producers are quoting $10 for No. 2, and for shipment during the last half of the year $11 has been named on a large tonnage. In the leading centers pig iron is quoted as follows: No. 2 foundry: Pittsburgh, $14.15; Cincinnati, southern Ohio brands, $14.20; Philadelphia, $14.50; Birmingham, $10 to $10.50; Cleveland, $13.25, and Chicago, local, $14. Basic: Philadelphia, $14.25, and Pittsburgh, $13.30. Malleable Bessemer, Pittsburgh, $13.90.

Bouquet for the Editor

TO THE EDITOR:—In the article entitled "Semi-Steel a Misnomer?" published on page 75 of the February issue of THE FOUNDRY, you make several statements which prove you have a firm grasp on matter pertaining to the metallurgical, as well as the commercial side of the foundry business. The first statement, "The largest engine builders are using semi-steel in their cylinders," interests me greatly, as I claimed 10 years ago that semi-steel, using manganese in the cupola, is the ideal metal for cylinder castings, because it is homogeneous, gives high tensile and transverse tests and does not develop the mass of sulphur cracks when finished as are contained in cylinders made from other cylinder mixtures. Today, many heavy gas engine cylinders are made in which 45 per cent of steel is used; and these cylinders are made in plants whose

executives only a few years ago declared, "Not a pound of steel will ever go into our cylinder mixtures." I have in mind a statement made by a machine shop manager, who said: "That cylinder (pointing to the casting) contains 40 per cent steel and cylinders never were made that can touch it; but it took Jack, our foundry foreman, months trying to convince me, before I would consent to allow him to try steel, but the results accomplished by him have proved that the country is 10 years behind the times in the manufacture of semi-steel castings." You also state: "It has been claimed that the charging of steel in the cupola, at best would give only an uncertain mixture—but results count. The product can be, and is closely controlled." These are the truest words ever spoken about semi-steel. "Closely controlled" applies to the use of 30 to 50 per cent steel scrap, more so than any other mixture melted in the cupola, and I challenge air furnace metal containing a larger percentage of steel scrap to meet the uniform analysis of semi-steel, day after day. There are many reasons why 30 to 50 per cent semi-steel can be "closely controlled." The primary reason is that the man in charge of the mixtures must be able to mix and melt iron scientifically and forget many of the old foundry traditions. You may be interested to learn that a foundryman in this city received an order recently for 44, 18-inch blank gears. He made 45 in case one would be lost, but there was one left, as every casting was finished in record time without a blemish: 45 per cent steel scrap costing $9.50 per ton, 40 per cent pig and 15 per cent semi-steel scrap were used in the mixture. Many open-hearth steel plants with iron foundry departments, purchase rolls and other special castings. It may interest steel manufacturers to learn that the writer has made high-grade semi-steel rolls, the metal having been melted in an open-hearth furnace. In fact this is the ideal method of making semi-steel for large castings.

DAVID MCLAIN.
Milwaukee Correspondence Schools, Milwaukee.

Pig Iron Brands Essential?

TO THE EDITOR:—Referring to the discussion of "The Chemical and Physical Properties of Pig Iron," by John Jermain Porter, published in the December 1911 issue of THE FOUNDRY, I do not favor relegating the foundry chemist to the background, nor am I in accord with the implied favoritism shown for pig iron brands. I will admit that the chemical analysis of an iron which is causing trouble is often insufficient to clear up the difficulties experienced, but the microscope is as much an adjunct to the chemist as his balance. It was only within the last few days that I was called upon to explain why a casting which ordinarily would be extremely soft, had an area in the center that was so hard that it was almost impossible to drill it, still at either end the casting was very soft. A microscopical examination of the two parts showed each to have an entirely different and definite construction. It has been my experience that when the castings in the foundry are shrinking, cracking, and what not, that the apparently unaccountable cause—and what the superintendent accredits to the brand of pig iron used—is in reality a condition brought about by the operation of the cupola, or may even be attributed to the molders. The following are actual analyses of two cars of iron (although both irons bear the same name), both cars being received on the same contract, from the same furnace, and yet are as different from each other as black is from white:

	Per cent.	Per cent.
Silicon	2.39	5.02
Manganese	0.60	0.98
Graphitic carbon	2.81	2.69
Combined carbon	0.27	none
Phosphorus	1.363	2.048
Sulphur	0.027	0.019

I have seen foundrymen who hesitated to use an iron because the analysis showed it to be a No. 1 grade, whereas it had been billed on the invoice as No. 2. Surely nothing could appear more ridiculous to the intelligent chemist than such superstition, which has resulted from the nomenclature applied to a certain grade of iron. The only conceivable reason, in my esimation, why one brand should be better than another, assuming both to be of similar analysis and adapted to the requirements of a particular class of work, is the management under which the blast furnace is operated. Suppose, then, a new superintendent is placed in charge, or that the iron ores are received from new fields. Is one still to adhere to the brand of iron merely for its name? Not long ago I had occasion to change the grade of iron melted in a certain cupola. In doing this the mixture was composed of three or four brands of iron never before melted in this furnace. The result of the first day's heat was a heavy loss, as nearly every casting with heavy sections developed large shrink-holes. Was this due to the brands of pig iron used? No, indeed. By changing the method of charging the second and succeeding heats have produced iron free from shrinkage. I have seen a molder experiencing all kinds of trouble in trying to prevent the cracking of a certain casting. The difficulty was not due to the brand of iron used, but was traced to the use of too small a flask. The outer portions of the casting cooled rapidly and internal strains were developed. In another case two identical patterns were being run in the same shop and were poured with iron from the same cupola; one molder produced 75 per cent of hard castings while the other molder had no trouble in pouring soft castings. The trouble was with the man and not the iron. Let us consider, for example, a casting with an inside chill, or white iron inside of gray iron. This seemingly strange phenomenon made itself evident some time ago in two kinds of castings from a heat of 20 tons. This could hardly be attributed to the brand of iron used, or it would have been more prevalent. Is it not probable that it was due to the particular shape of the castings, the condition of the solution of the carbon in the iron and the temperatures at which the castings were poured and cooled? I am now making experiments to ascertain the actual cause of inside chilling. Unfortunately, the brands of pig iron used have been assigned as the cause of defective castings in many instances in which the losses were subsequently traced to bad melting and worse methods of molding.

WALTER H. WIARD, Chemical Engineer,
Chicago Hardware Foundry Co., Chicago.

Equipment for the Foundry and Pattern Shop

Improved Core Machine—Power Turn-Over, Power Draft Molding Machine—Plain Jar-Ramming Machine—Portable Power Squeezer

THERE are three general types of core machines in use in this country.

In the first type the sand is forced through a die forming round, square or irregular shaped cores with parallel sides; the second type is similar to the ordinary roll-over or jolt-ramming machine in which the core box takes the place of the pattern, while in the third type the sand is rammed into the core box by air pressure. The Hewlett core machine, manufactured by Wm. Demmler & Bros., Kewanee, Ill., is an example of the third type. An improved model of this machine has recently been placed on the market, the details of which are shown in the accompanying illustrations.

Referring to Fig. 1, the sand is placed in the cylindrical holder shown in the foreground, from which it is carried by a simple elevator to the upper sand hopper located at the top of the machine. The holder has a capacity of three cubic feet. The sand is fed to the elevator by a graduated feeding device which can be regulated to furnish the proper quantity for cores of any size. From the upper hopper the sand passes into the lower or feeding hopper, *H*, Fig. 1. This hopper is secured to the under side of a sliding plate, *X*, which is worked slowly back and forth by a crank and link-work attached to the fly-wheel. When the plate, *X*, is at one end of its stroke, hopper, *H*, is in communication with upper hopper and is filled; when the plate is at the opposite end of its stroke, compressed air is admitted to the hopper through the valve, *V*. The hopper, which is now directly over the core box held in the chuck on the table, *T*, has a flat plate across the bottom through which two small holes are drilled. The pressure of the air forces the sand through these holes into the core box. If the upper surface of the core is flat, this plate serves for the top of the core box; if the core is irregular, the box is closed on top, two holes being left for the admission of sand through the bottom of the feeding hopper.

The table, *T*, is adjustable and is provided with an automatic compressed air chuck which holds the core boxes securely while they are being filled and releases them as soon as the operation is completed. The valves controlling the admission of air to the chuck and feeding hopper are operated automatically by cams on the fly-wheel.

The sand in the upper hopper is kept from sticking by a revolving cutter. The machine is driven by a belt to a 16-inch clutch pulley running about 30 revolutions per minute. The fly-wheel, to which the crank and cams are attached, is so geared to the clutch pulley that it operates about 8 revolutions per minute.

The sliding plate, *X*, carrying the feeding hopper, therefore, makes about eight strokes and fills eight core boxes every minute. There may be several cores in each box. The frame of the machine is cast iron, box section, and is about 6½ feet high and 5 feet wide. The floor space required, including elevator, is approximately 30 square feet. Cores of very irregular shape can

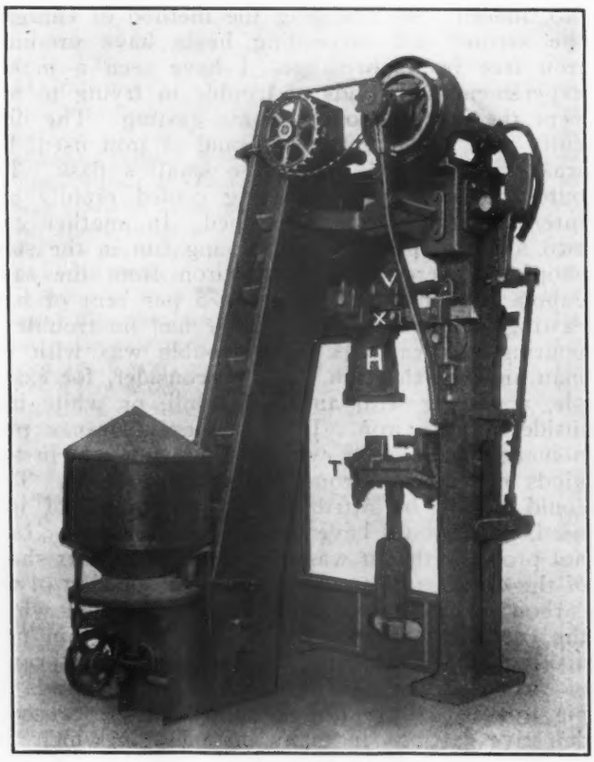

FIG. 1—HEWLETT CORE MACHINE, SHOWING SAND ELEVATOR

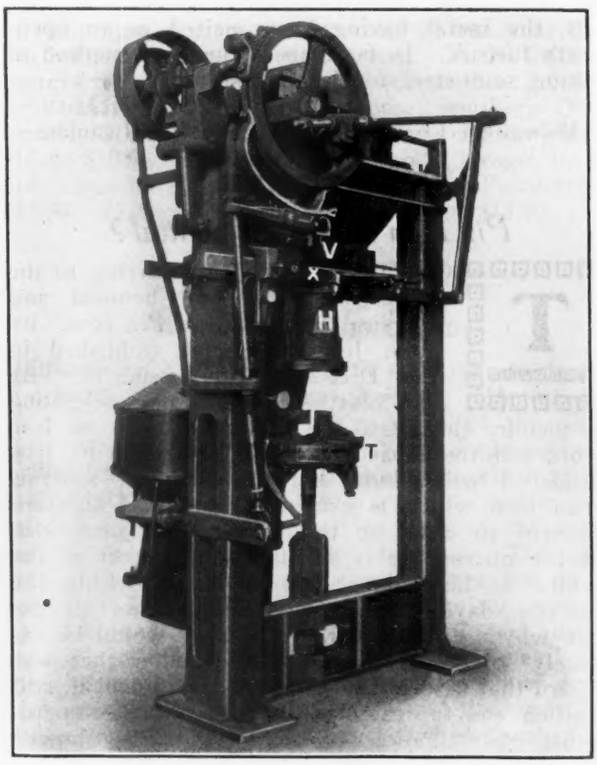

FIG. 2—CORE MACHINE, SHOWING FEEDING HOPPER AND TABLE

be made as easily on the Hewlett machine as plain ones, the air forcing the sand into pockets and angles in the core box. They may be made of oil sand, rosin mixture, glutrin mixture, with a moderate quantity of flour, or of green sand. The pores are very fine, yet allow a good natural vent for the gases. It is claimed about 95 per cent of the cores made by this machine do not require additional venting.

In operating the machine, 80 pounds per square inch air pressure is required for oil and silica sand mixtures; 90 pounds for oil mixtures containing loam, while mixtures using rosin, glutrin or flour require 100 to 115 pounds pressure. Where the line pressure in a plant is below these figures, a small auxiliary booster compressor is used.

The machine requires one horsepower to drive it and consumes about 12 cubic feet of free air per minute. It will make cores from 1 inch to 15 inches in length and will fill boxes using as much as 200 cubic inches of sand.

The J. W. Paxson Co.

At the annual meeting of the J. W. Paxson Co., Philadelphia, officers were elected as follows: H. M. Bougher, president and general manager; Howard Evans, vice president; S. C. Bougher, treasurer and purchasing agent; Sherman Bougher, secretary; F. B. Platt, assistant secretary and treasurer; J. S. Hibbs, assistant general manager; James L. Crawford, marine superintendent, and A. G. Warren, mechanical engineer of plants.

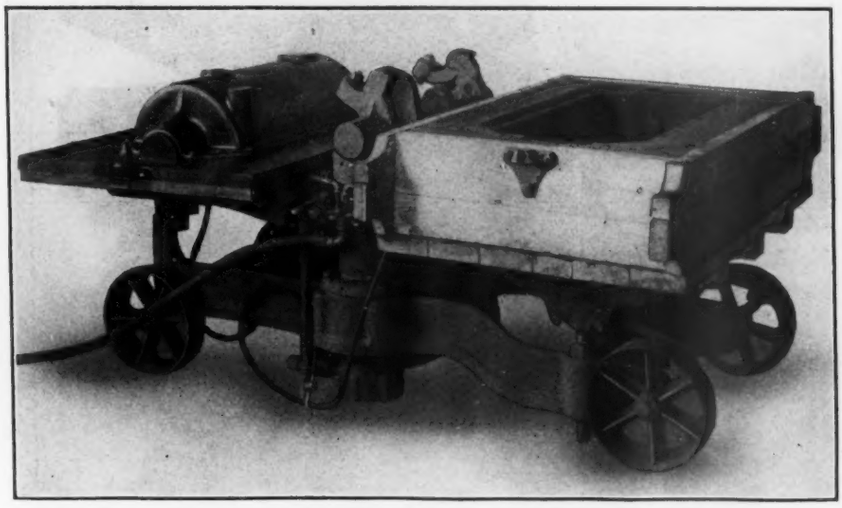

FIG. 1—POWER TURN-OVER, POWER DRAFT MOLDING MACHINE ON WHICH THE PATTERN FOR AN AUTOMOBILE OIL PAN IS MOUNTED

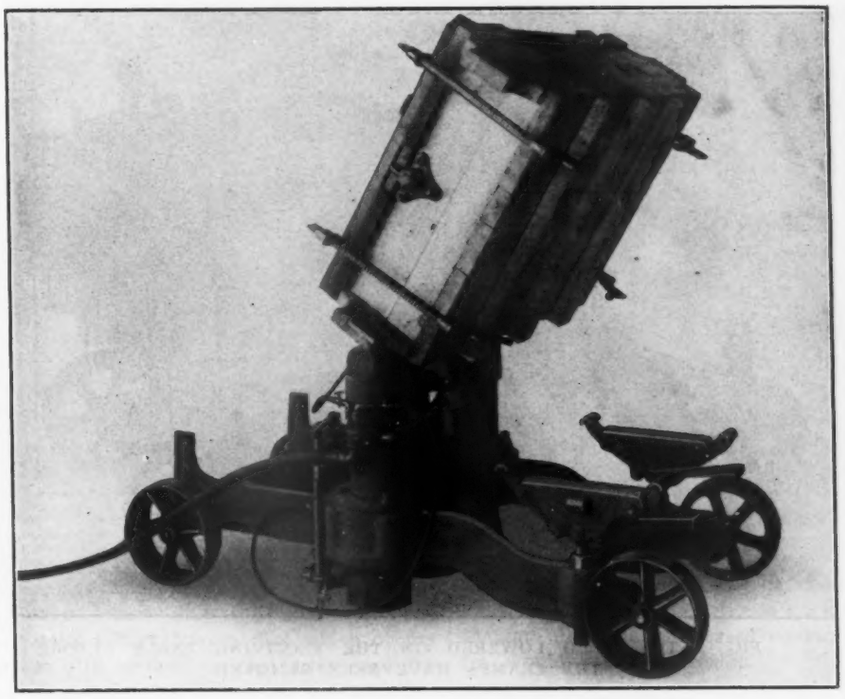

FIG. 2—TURNING OVER THE MOLD

A New Power Turn-Over, Power Draft Molding Machine

A power turn-over, power draft molding machine on which separate cylinders are employed for turning over the mold and for drawing the pattern, built by the International Molding Machine Co., 2300-2318 South Western avenue, Chicago, is shown in the accompanying illustrations. In none of the operations of the machine are the drawing and turn-over cylinders used simultaneously, and as it requires a lower air pressure to draw the pattern than is employed for turning over the mold, the use of separate cylinders, it is claimed, effects a reduction in the consumption of air as compared with machines employing the same cylinder for rolling over the mold and drawing the pattern. Two small cylinders are used for the pattern-drawing operation and one cylinder has been provided for turning over the mold. The arrangement of the drawing cylinders, one on each side of the machine, furthermore precludes the possibility of the pattern swaying or sagging while it is being drawn from the mold.

The machine consists essentially of a heavy cast iron frame composed of two side rails connected at both ends by cross rails. These, with their adjacent parts, form at one end the ramming bed and at the opposite end. the receiving table. At the centers of the side rails are cast large, round sockets which receive the two side cylinders. These sockets are accurately machined on their upper surfaces. The annular flanges on the cylinders are machined on their lower surfaces, and when the cylinders are set in place they are held in a true, perpendicular position by the two contacting machined surfaces. The turn-over pattern frame revolves on a heavy steel shaft which is driven into two cast iron hubs which form the tops of the pistons on the drawing cylinders. Integral with these hubs are two sets of heavy bearings or stops, so arranged as to engage corresponding bearings or stops on the turn-over frame. One set of stops on the turn-over frame is adjustable and is used to locate the plane of the pattern at the proper

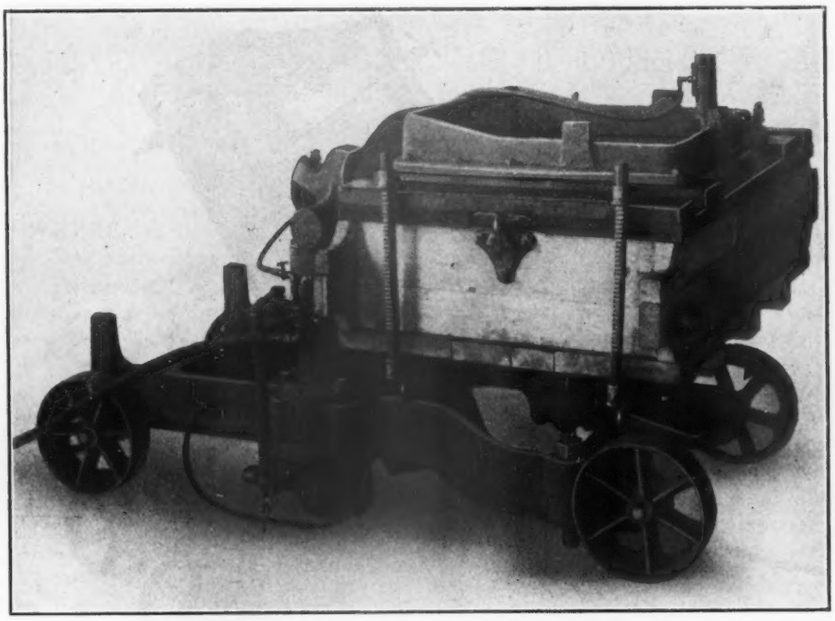

FIG. 3—THE MOLD LOWERED ON THE RECEIVING TABLE BEFORE THE CLAMPS HAVE BEEN REMOVED

angle with relation to the drawing cylinders, so as to insure a perfect draw. The other set of bearings serves to properly limit the action of the turn-over frame when it is swung back onto the ramming bed. The turn-over cylinder is held in position by the trunnions on either side, which are journaled in sockets cast into the sides of the two drawing cylinders.

The receiving table of the machine is provided with two flask receiving devices, the height of which can be adjusted to the depth of the flask used. The four points of contact act independently of each other so as to compensate for irregularities in the bottom boards. The locking lever is so located that the operator can easily reach it without being obliged to change his position. Furthermore, the locking mechanism is so designed that it is impossible for the surfaces on which the mold rests to spring out of position until different equalization is required.

In Fig. 1 the pattern of an automobile oil pan is shown mounted on the turn-over pattern frame which is in position on the ramming bed. After setting the flask in position, ramming the mold, and clamping the bottom board to the pattern frame, air is admitted to the turn-over cylinder by the full movement of the lever actuating the valve on the turn-over cylinder. This air valve controls the movement of the mold to the position shown in Fig. 2, which is just past center. When the mold attains the position illustrated in Fig. 2, the air is exhausted from the turn-over cylinder and the mold is lowered onto the receiving bed, as shown in Fig. 3. After locking the two flask receiving devices, the clamps are removed and air is admitted to the pattern-drawing cylinders, the patterns being drawn from the mold as illustrated in Fig. 4. When the limit of draw has been reached, which is controlled by the length of the turn-over cylinder piston shaft, the turn-over frame automatically begins to turn back to its original position and as it passes center, the air is exhausted and the pattern frame is lowered onto the stops of the ramming bed, as illustrated in Fig. 6, which also shows the mold ready to be removed to the floor. Fig. 5 shows the pattern frame in its movement back to its original position.

In designing this machine, the International Molding Machine Co. has endeavored to provide for the convenience of the operator, for the acceleration of the speed of operation for the varying conditions under which the machine will be used, and for molding a wide variety of patterns. Separate levers are provided for actuating the valves on the turn-over and pattern-drawing cylinders. The valves have been so designed that neither oil nor water pressure is required to facilitate the operation of the machine. All parts requiring lubrication are easily accessible and all sections subjected to strain are made of steel. Machines of the same size are interchangeable, both as to different parts used in their construction and the mounting of the patterns.

These machines are built in six sizes with turn-over frames varying in width from 26 to 36 inches and with draws of from 8 to 14 inches. The machine illustrated has a 30-inch frame and an 8-inch pattern draw. The weight of the mold is 1,000 pounds.

The Corrosion of Manganese Propellers

The extensive use of manganese bronze propellers on ocean steamers is due to its freedom from corrosion, to which both iron and steel propellers are subject. This immunity to corrosion, however, as pointed out by *Engineering*, does not

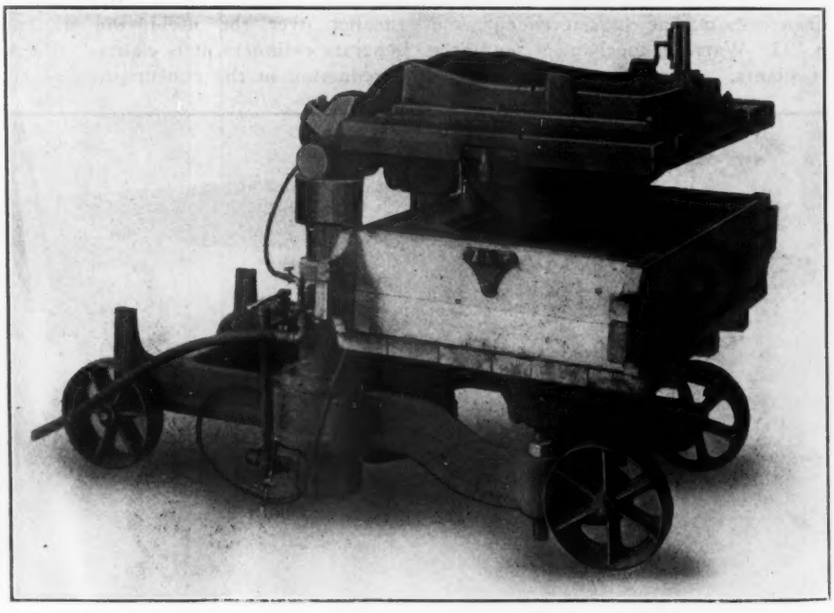

FIG. 4—THE PATTERN DRAWN FROM THE MOLD BY THE TWO AIR CYLINDERS

extend to vessels driven by turbine engines, as in the latter case, the same alloy that formerly gave satisfactory results, rapidly corrodes. The trouble is supposed to be due to the more rapid rotation of the propellers driven by turbines. It is a remarkable fact that an alloy that has been entirely free from corrosion when working at a certain speed, should be attacked with extraordinary rapidity when the speed is increased. On turbine-driven steel propellers the metal was eaten away back of the blades not far from the tips, while on manganese bronze propellers the corrosion appeared on the faces of the blades and near the hubs.

The serious character of this corrosion, from a financial point of view, will be appreciated when it is considered that a manganese bronze propeller costs from $650 to $900 a ton. The weight of each propeller is about 20 tons and the cost of each, in round figures, is from $13,000 to $18,000. The value of the scrap in old propellers is less than one-half the cost of new propellers, and as the latter had to be replaced every few months where formerly they had often oulasted the vessel, it became imperative that some solution of the difficulty should be found.

The Investigation

A thorough investigation of the whole subject was made by the Manganese Bronze & Brass Co., Ltd., London, and Dr. O. Silberrad, a noted metallurgist, was commissioned to conduct the researches. When the damaged propellers were examined it was found that the corrosion was quite different from that which occurs in still water. In the latter case the dissolution is selective in character, the zinc being dissolved and a spongy mass, rich in copper, is left. In the case of the eroded blades, analyses showed no copper enrichment, as the metal was of the same composition throughout. There was one special peculiarity, however, that finally led to the discovery of a remedy, and this was the fact that while there was no wasting of one component metal more than another, while the main mass of the alloy, consisting of mixed crystals, was unaffected, the eutectic of the alloy was washed away. It was thus proved that the susceptibility of the alloy to corrosion was dependent upon its structure, and it was decided that an alloy that possessed no eutectic would resist corrosion.

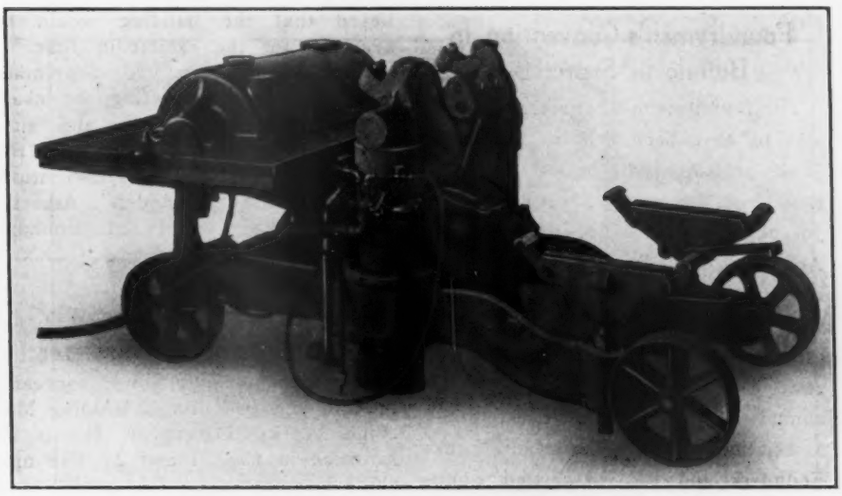

FIG. 6—THE PATTERN TURNED BACK TO RECEIVE A FLASK, AND THE MOLD READY TO BE REMOVED TO THE FLOOR

FIG. 5—TURNING BACK THE PATTERN IN A POSITION FOR MAKING ANOTHER MOLD

Problem of Obtaining New Alloy

The difficulty, however, was to combine the required structure with the requisite tensile strength. The problem of obtaining a new alloy would have presented no difficulties if a tensile strength of 35,000 pounds per square inch would have sufficed, but in this case from 85,000 to 90,000 pounds was required. A large number of tests were made and the resistance to corrosion was increased step by step until finally an alloy wes perfected that had an endurance five times greater than the ordinary manganese bronze. The new alloy was named Turbadium, and the new propellers for the Mauretania were cast from this metal. After being in service for periods ranging from one to three years, these propellers were found to be practically unaffected by corrosion.

The New Alloy

The analysis of the new alloy is not given, but as the investigation was conducted with a copper-zinc alloy to determine what additions of other metals could be made to a simple brass without giving rise to a eutectic, the new metal undoubtedly belongs to the copper-zinc series of alloys, and bears no relation to the copper-nickel and chrome-copper-nickel group of high tensile alloys, recently developed.

The analysis of the manganese bronze made by the Manganese Bronze & Brass Co., London, is as follows: Copper, 57.73 per cent; zinc, 39.81 per cent; aluminum, 0.20 per cent; iron, 1.04 per cent; tin, 1.14 per cent; lead, 0.13 per cent, and manganese, a trace.

Foundrymen's Convention in Buffalo in September

The foundrymen's convention, which was to have been held in Buffalo in June, probably will be postponed to the week beginning Sept. 9. Maj. Joseph T. Speer, president of the American Foundrymen's Association, is now endeavoring to obtain the views of the members of the executive committee of this organization relative to the postponement of the annual meeting date. Of the allied associations, the American Brass Founders and the Associated Foundry Foremen have already agreed to hold their annual gatherings in September.

As no satisfactory building would be available in June for the exhibit of foundry supplies and equipment which was to have been conducted by the Foundry & Machine Exhibition Co., at the time of the meetings of the allied foundrymen's associations, it became necessary either to eliminate this feature of these gatherings, or to postpone the date of the conventions. The Broadway Exposition building, Buffalo, where the foundry show is to be held, is now undergoing extensive repairs which cannot be finished until mid-summer, although when this work was undertaken several months ago, it was believed that the building would be available for the exhibit in June.

The postponement to September will permit of conducting the usual foundry equipment show and simultaneous annual meetings of the American Foundrymen's Association, American Brass Founders' Association and the Associated Foundry Foremen, will be held.

A Portable Power Squeezer

A 10-inch, portable power squeezer, built by the E. Killing's Molding Machine Works, Davenport, Ia., is illustrated in Figs. 1 and 2. The machine is mounted on four wheels and can readily be moved along the floor following the sand heap with the progress of the day's work. The machine has an exceedingly wide base and provides ample room for the operator to move about without being interfered with by any of the machine parts. The cylinder and yoke trunnions are supported at a sufficient height to prevent them from coming in contact with the sand heap. The plunger cannot be blown out, as it is amply protected with lock nuts. This machine is equipped with a blow-off valve and knee vibrator as well as an air gage for regulating the pressure desired for different classes of work. In Fig. 1 the machine is shown with the crosshead thrown back and in Fig. 2 a snap flask is in position on the table ready for ramming. This type of machine is made in several sizes and is adapted for all classes of snap flask work, making both cope and drag in one operation.

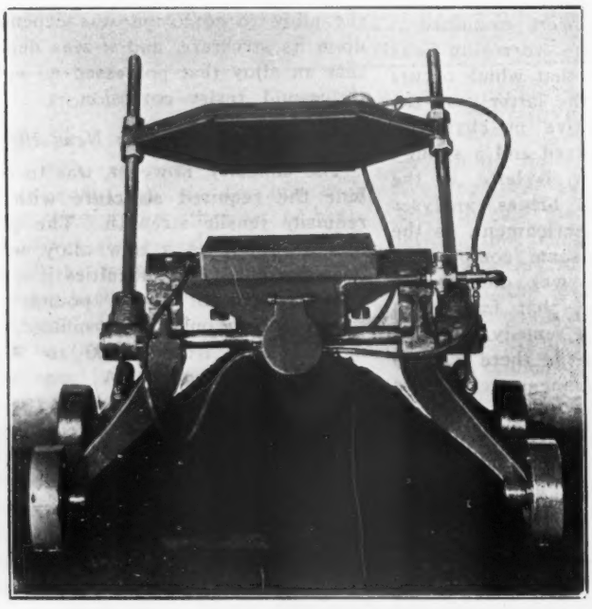

FIG. 1—PORTABLE SQUEEZER WITH CROSSHEAD SWING BACK

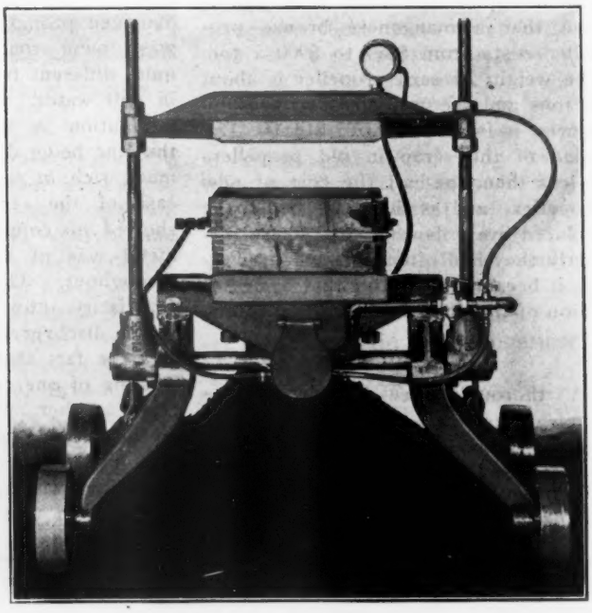

FIG. 2—PORTABLE SQUEEZER IN RAMMING POSITION

Brass Founders' Association

At a recent meeting of the executive committee of the American Brass Founders' Association held in Buffalo, Secretary W. M. Corse presented a report on the co-operative work contemplated by the United States bureau of standards and the bureau of mines with the association Prof. Charles L. Parsons, chief mineral chemist of the bureau of mines, attended the meeting and stated that the investigation of problems connected with the manufacture of nonferrous alloys would be undertaken. A committee consisting of G. H. Clamer, chairman, Harvey J. Skinner and Jesse L. Jones was appointed to co-operate with the bureau of standards and another committee consisting of H. W. Gillett, E. B. Horne, and I. M. Bregowski, will co-operate with the bureau of mines.

The Anderson Oil Co.

The Anderson Oil Co., Buffalo, has been incorporated with $25,000 capital to engage in the manufacture of high grade core oils and foundry supplies. The incorporators of the company are C. M. Anderson, formerly with the National Core Oil Co., Buffalo, and Harry H. Hoover, previously associated with the T. J. Peterson Co., Chicago. A manufacturing building, 162 x 175 feet, located at Swan street and the New York Central railroad main line has been obtained. A rail-

road siding extends into the yard of this plant.

Plain Jar-Ramming Machine

A plain jar-ramming molding machine, which is exceedingly novel in design and construction, is shown in the accompanying illustrations. This machine is unique, as it contains no valves and is without ports other than the exhaust. The only valve required is that on the air line which controls the air supply to the machine. This molding device has been especially designed to effect operating economies and this has been accomplished by reducing the air consumption to the minimum and by the elimination of mechanism which might require frequent repairs. The base, cylinder and table are of heavy construction and have been designed to meet all the severe service requirements of the foundry.

The table, plunger, cylinder and base are separate castings and studs in place of bolts or cap screws are employed to fasten together the plunger and table and the cylinder and base. All joints are scraped to insure an absolutely air tight fit, thereby eliminating the use of gaskets. The contact surfaces of the jarring mechanism are large and form a concentric ring around the piston and at such a distance from the center of the machine as to minimize the effect of unequal loading on the table.

Notwithstanding the fact that the machine shown in Fig. 1 is equipped with an 8-inch cylinder, the overall height, from the base to the top of the table, is only 21 inches. In Fig. 1 the exhaust pipe is shown at the left and the air supply pipe, at the right. In this illustration the table has been raised to show the length of the stroke, which is 3½ inches, but machines are built also with a 5-inch stroke. Two adjustable stops are attached to the machine on either side, which also serve as guides, insuring perfect alignment. In Fig. 2, the machine is shown with a pattern plate and pattern on the table. The pattern has a depth of 16 inches, but notwithstanding the difficulties involved in molding a model of this form, molds have been successfully jar-rammed on this machine more satisfactorily and in much less time than could be done by hand. The flask in which this pattern was molded is 31 x 47 inches inside and 22 inches high.

This type of plain jar-ramming molding machine, which is equally well-adapted for making molds and cores, is built in all sizes by the U. S. Molding Machine Co., Cleveland, recently organized by J. N. Battenfeld.

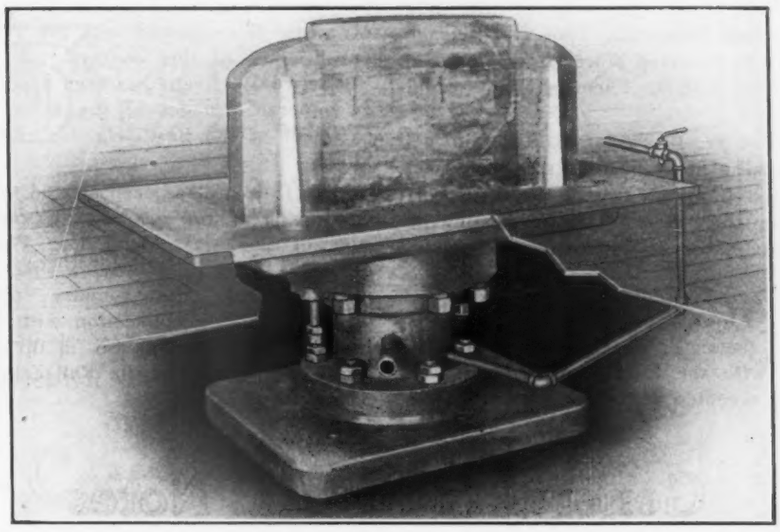

FIG. 2—JAR-RAMMING MACHINE WITH PATTERN PLATE AND PATTERN ON THE TABLE

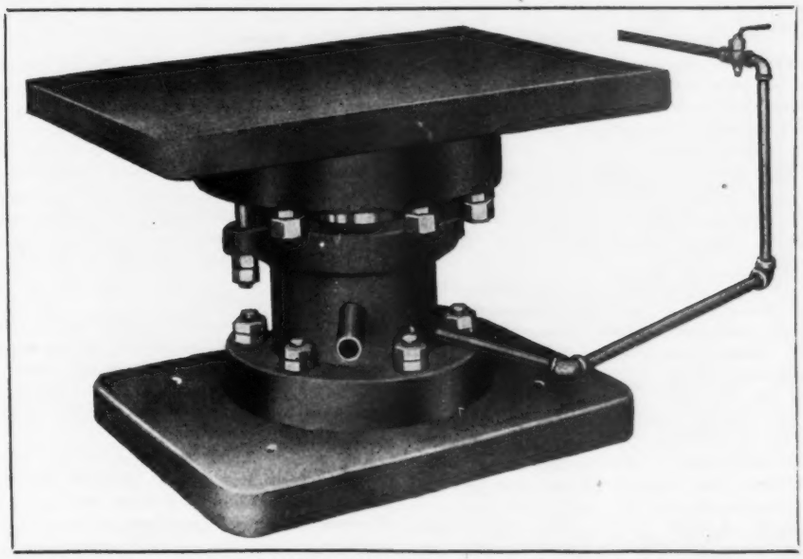

FIG. 1—PLAIN JAR-RAMMING MOLDING MACHINE WITH TABLE RAISED

The Vulcan Engineering Sales Co.

The Vulcan Engineering Sales Co., recently incorporated, will handle exclusively the sale of the products of the Hanna Engineering Works, Chicago, Mumford Molding Machine Co., Plainfield, N. J., and the Q. M. S. Co. of New York. Offices have been established in the Fisher building, Chicago, and at 30 Church street, New York City. The manufacturing facilities of the Vulcan company are to be increased and its line of equipment will be extended to include special railway tools for shop and maintenance departments.

H. K. Gilbert, formerly vice president of the Buda Co., has been elected president and T. W. Gates, president of the Hanna Engineering Works and formerly president of the Gates Iron Works, is secretary and treasurer. E. H. Mumford, vice president and general manager of the Mumford Molding Machine Co., will continue in the same position and will perform the same duties as heretofore, and William L. Laib, vice president and secretary of the Hanna Engineering Works, will continue in his present position with that company.

Trade Notes

The Avery Stamping Co., Cleveland, is sending cards to the trade illustrating samples of heavy, intricate drawn work.

The Pittsburgh office of the Independent Pneumatic Tool Co., Chicago, will be removed March 1, from 1426 to rooms 1208-09 Farmers Bank building.

The W. P. Taylor Co., Buffalo, will install a Stock oil-fired steel converter. This converter utilizes the waste heat from the converter for pre-heating the blast employed in blowing the steel.

Personal

Coleman B. Ross, formerly associated with the Linde Air Products Co., has accepted a position with the Independent Pneumatic Tool Co., Chicago. Mr. Ross is connected with the Pittsburgh office of this concern.

Howard W. Evans has been appointed general manager of the sales department of the Best Mfg. Co., Pittsburgh.

Wm. J. Coane has been elected third vice president and general sales manager of the Ajax Metal Co., Philadelphia. Mr. Coane enjoys a wide acquaintance in the foundry trade through his long connection with the Joseph Dixon Crucible Co. in the capacity of manager of the Philadelphia office.

General Industrial Notes

The Saskatoon Foundry & Machine Co.'s plant, Saskatoon, Sask., has been sold to the Western Foundry & Machine Co., Ltd.

The Western Steel Car & Foundry Co. has purchased the plant and a 100-acre tract formerly owned by the Illinois Car & Equipment Co., located near the Calumet river in the Chicago district.

The Southern Foundry & Machine Co., Lexington, Tenn., has been incorporated with a capital of $10,000, by A. E. Beasley, C. G. Gathings, T. A. Lancaster and W. H. Lancaster.

The Peterborough Model Foundry & Mfg. Co., Ltd., Peterborough, Ont., has been incorporated with a capital of $40,000. The incorporators are Thos. H. Ruble, John Condon and Wm. H. Pethick.

The new plant of the G. E. Hoglund Foundry Co., Gardner, Mass., is now in operation and the company is in position to make deliveries of gray iron and brass castings of any size and description.

The Keystone Steel Castings Co., Chester, Pa., is installing a four-ton, open-hearth oil-fired furnace. When this furnace is in operation the company will be in position to furnish both open-hearth and crucible steel castings.

The Industrial Works, Bay City, Mich., are completing the installation of a two-ton Tropenas converter plant, which has a capacity of 8 to 10 tons per day. The company has made extensive additions to its foundry and a complete equipment of saws and other accessories has been installed.

Max K. Weigel, president of the Central Foundry Co., Oklahoma City, Okla., has organized a new company to be known as the United Foundry Products Co. This concern is capitalized at $100,000 and will operate a malleable foundry for the manufacture of rail joints and patent tie plates.

New Construction

W. Hillard is erecting a foundry, 41 x 66 feet, at Greensburg, Ind.

The Palmetto Iron Works, Greenville, N. C., will erect a foundry, 40 x 117 feet.

S. L. Williams & Sons, Greenville, Tenn., contemplate the erection of a foundry and machine shop.

The American Foundry & Furnace Co., Bloomington, Ill., is erecting an addition to its plant, 40 x 50 feet.

The Fulton Machine & Vise Co., Lowville, N. Y., is completing plans for an addition to its foundry.

McGregor & McIntyre, Pearl street, Toronto, Ont., will erect a new foundry at a cost of $50,000.

Wm. J. Lyles Jr., Middletown, O., will erect a plant at Nashville, Tenn., for the manufacture of malleable iron and steel castings. The cost is estimated at $200,000.

The Burr Co., Champaign, Ill., has succeeded to the business formerly conducted by E. M. Burr & Co. A foundry and structural shop are being erected.

The Chicago Steel Foundry Co., Chicago, will erect a crucible steel plant, which will consist of a foundry, 130 x 200 feet and a pattern storage and office building, 22 x 152 feet.

The Western Steel Foundry Co. has purchased the Colorado Gray Iron Foundry, Denver, Colo. The plant will be rebuilt and a steel casting department will be added.

The Camden Water Wheel Works, Camden, N. J., is planning the erection of a foundry, 100 x 150 feet and a boiler shop, 50 x 150 feet. Two electric cranes of 10 and 15 tons capacity, respectively, will be required.

The Globe Malleable Iron & Steel Co., Syracuse, N. Y., whose foundry was recently destroyed by fire, has plans under way for rebuilding its plant, which will be almost entirely of fireproof construction.

The Tuttle-Bailey Mfg. Co., Cleveland, is having plans prepared for a foundry and machine shop to be erected at Bridgeburg, Ont. This concern manufactures registers for hot air heating systems.

The Seattle Car Mfg. Co., Seattle, has changed its name to the Seattle Car & Foundry Co. Extensions will be made to its plant at Renton, Wash., and a 5-ton cupola will be installed.

Marsh & Henthorn, Ltd., Belleville, Ont., manufacturers of hoisting machinery, are having plans prepared for a new plant, which will consist of a foundry, 50 x 80 feet, machine shop, 60 x 120 feet, boiler shop, 60 x 120 feet and several other buildings.

The Raleigh Iron Works Co., Raleigh, N. C., is considering the erection of a malleable iron foundry. This company now manufactures gray iron and brass castings and operates large machine and pattern shops.

McNey & Duff, Terrell, Tex., will remove their large foundry and machine shops to Temple, Tex., where a new foundry, 40 x 80 feet and machine shop, 32 x 80 feet, will be erected, in addition to a pattern shop, blacksmith shop and other small buildings.

The United States Cast Iron Pipe & Foundry Co. is making extensive improvements to its Bessemer, Ala., plant, which entail an expenditure of $300,000. The Dimmick foundry at North Birmingham, also operated by the United States Cast Iron Pipe & Foundry Co., is being rebuilt at an estimated cost of $150,000.

The Pratt & Letchworth Co., Buffalo, is having plans prepared for a new malleable foundry, 225 x 550 feet. The new building will replace the old wooden buildings which have been added from time to time and will be erected in sections to avoid interference with operations. The foundry will be equipped with a trolley system and waste heat boilers will be installed in connection with the melting furnaces.

Among the Brass Founders

The C. O. Clark Co., Montreal, Can., will erect an addition to its brass foundry.

The Lancaster Foundry Co., Lancaster, Pa., is contemplating the addition of an electroplating department.

The firm name of the Brass Foundry & Heating Co., Peoria, Ill., has been changed to the Brass Foundry Co.

The Youngstown Bronze & Iron Foundry Co., Youngstown, has completed an addition to its foundry, 100 x 136 feet.

The Kretschner Mfg. Co., Dubuque, Ia., manufacturer of brass and aluminum castings, is erecting a two-story plant, 80 x 100 feet.

The Anderson Brass Co., Anderson, Ind., has been organized to engage in the manufacture of brass and aluminum castings. The incorporators are J. B. Hart, W. C. Hogwood, G. W. Hogwood and others.

The Columbia Brass Works, Los Angeles, Cal., is erecting a two-story brass foundry, 50 x 117 feet. This concern is making a specialty of bronze automobile bushings.

The Chattanooga Brass Mfg. Co., Chattanooga, Tenn., recently organized, has purchased the plant and business of the Eagle Brass Works of that city, which is located at 406 Boyce street.

The Hammond Brass Works, Hammond, Ind., has been incorporated with a capital of $35,000, to engage in the manufacture of brass valves. The incorporators are C. H. Mayer, J. E. Brennan, W. Wolter, J. F. Lammering and U. G. Cassady.

The Frederick-Ruggles Mfg. Co., Louisville, Ky., manufacturer of measuring devices, has recently added a nickel-plating department to its plant and, in addition, the brass foundry of this concern has also been enlarged, two additional furnaces having been installed.

The Worcester Ornamental Iron Co., Worcester, Mass., manufacturer of ornamental iron, brass and bronze castings, will lease the buildings formerly occupied by the Harris Car Co. on Grafton street, to provide for increased facilities.

Wm. C. Buckelew, 304 Golden Hill street, Bridgeport, Conn., is organizing a new brass foundry company and will shortly erect a large plant at Bridgeport. Mr. Buckelew was formerly treasurer of the Fairfield Aluminum Foundry Corporation.

The Anchor Brass & Aluminum Co., Cincinnati, incorporated with a capital of $10,000, has leased a building on Colerain avenue, near Harrison street, and has placed its foundry in operation. This concern will engage in the manufacture of brass, aluminum and alloy castings.